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BULLETIN

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CHICAGO ACADEMY OF SCIENCES.

GLACIAL MARKINGS OF UNUSUAL FORMS

IN THE

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By EDMUND ANDREWS, M. D., LL.D.

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BULLETIN
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CHICAGO ACADEMY OF SCIENCES.

GLACIAL MARKINGS OF UNUSUAL FORMS IN THE LAURENTIAN HILLS.

BY EDMUND ANDREWS, M. D., LL.D.

Two summer vacations spent in camps and canoes where the Laurentian Hills skirt the northeast shore of Lake Huron, have brought to my notice some glacial phenomena of very unusual forms.

These hills are for the most part ranges of hard metamorphic rock, which at the boulder drift period were scraped bare and washed clean of all earthy covering, so that the present forests grow mostly in a thin stratum of vegetable mold of later origin. The irregular and knobby eminences, as the country slopes gradually beneath the level of Lake Huron, project their countless summits above the water in a wide belt of wooded islands, which extend along the coast some two hundred and fifty miles. The British chart (Bayfield's original) marked fifty-two thousand of these islands. The rocks along the coast are mostly white quartzite and gneiss, and are everywhere covered with glacial markings which are often of peculiar forms. North and northeast of Grand Manitoulin Island the Cloche Mountains stretch east and west about thirty miles along the coast. These mountains are of white quartzite, and the strata are nearly perpendicular, with the strike parallel to the range, that is, east and west. They are covered everywhere with striations which, owing to the intense hardness of the material, retain their forms with beautiful distinctness.

CURVED STRIÆ.

Among the interesting phenomena of the region are the thousands of curved striations. Fig. 1 is from the stream that comes down by the Hudson's Bay Post, about fifteen rods above the cascade. There is a broad gap here in the Cloche range, through which some fine lakes lying behind the mountains send their surplus waters to Lake Huron. The stream apparently ran in the same bed before the drift period, for the little gorge at D, (indicated in the figure by shading,) scarcely ten feet deep, is well scored to the very bottom with glacial striæ following all the sinuosities of the stream. The general course of the striæ of the gap is southward. The perpendicular lines in the figure indicate this general direction, while the curved lines in the shading of the gorge (D) show how the striæ bend abruptly in order to follow around the hard quartzite banks of the stream, and, in doing so, even run a little contrary to the main course of the glaciation.

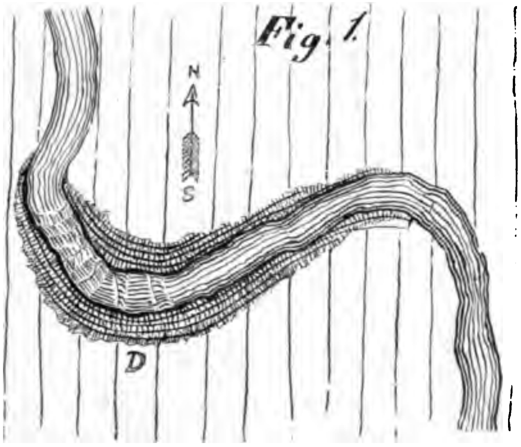


Fig. 1

The crest of the Cloche Mountains is crossed by a multitude of giant grooves, some of which reach a depth of six feet and are twenty feet across. These markings run southward, rounding slightly over the summit of the range and down its slopes, until they reach the crests of its southern precipices, where they terminate abruptly, as it were sailing away into the air and not forming any grooves down its face.

Sixty miles southeast of the Cloche gap, and off the mouth of French River, there lies outside of the general insular belt a beautiful cluster of wooded islets, the Bustard Isles. The group consists of about two hundred *roches moutonneés*, upon which sufficient vegetable mold has accumulated to support a growth of trees. Wherever this soil has been washed away by the waves, the striæ come to view.

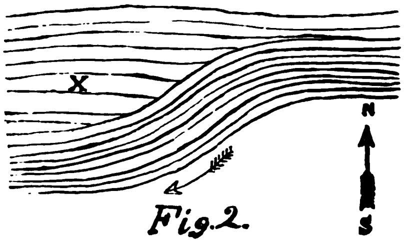


Fig. 2.

Fig 2 was sketched from a sample of curved markings near one of my camps on the north side of the group. The sketch represents about fifteen feet of the length of the marks. It is not easy to see any reason for the curve, as there was no prominence of rock in the direction of x to turn the ice. In fact the islet was highest on the side toward which the ice turned at the first curve. The compass-mark is approximately, but not precisely correct.

Fig. 3.

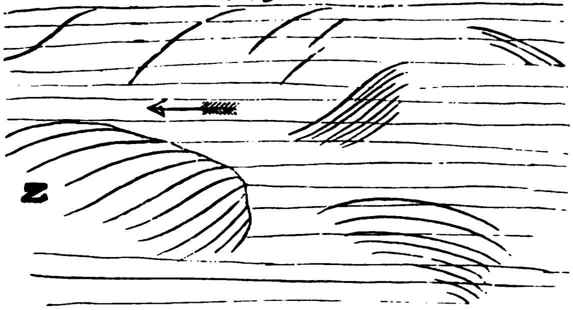
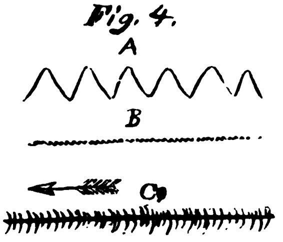


Fig. 3 is copied from my notes of observation on striæ found at Negaunee, in northern Michigan. A knob of rock uncovered by iron-miners was of such material that it showed on its irregular surface the finest markings, even to hair-lines.

There were upon this rock some curves, which were evidently deflections caused by knobs and bosses on its surface, as for instance at z, while other markings were erratic, and curved without obvious cause, as though the ice had been swayed by swirling currents as the waters moved about it. The most of the glaciation was in the direction shown by the horizontal lines. The curved lines in the figure were selected from hundreds of others on a surface of about two rods square. They were generally short, and some of the curves were of less than one foot radius.

SERRATED STRIÆ.

Fig. 4.



Behind the Cloche Mountains the Spanish River runs westward into Lake Huron. A branch of this stream, called the Sable, coming down from the hills on the north, presents near its mouth five cataracts within a distance of eight miles. At the lowest of the falls the river runs through a sort of rock flume, having upon both sides walls about forty feet in height, not quite vertical but with a slight inclination away from the stream. These cliffs are smooth and striated in every part parallel to the stream. At the falls, which are only a few feet in height, the striæ curve with the descent, and also laterally with a bend of the cliff. On the walls of the gorge are to be seen a few examples of the marks A and B, fig. 4, and the mark A is serrated, the serrations being perhaps twelve inches high.

It is not easy to explain the cause of these striæ in a perfectly satisfactory manner, but it would seem that some of the ice must have been driven through the flume with a rocking motion, so that the boulders on its lateral margins were caused to take a zigzag course, scoring the walls in a corresponding form. In B, fig. 4, is represented a section of certain marks produced in the same manner as those cuts of a stone-planing engine where the tool trembles or vibrates in the grasp of the machine so as to cut a finely serrated groove. In the specimens found the serrations were about one-quarter of a centimetre from crest to crest. It is possible that the regular vibrations there recorded on the rocks had some fixed mathematical relation to the velocity of the ice, which might be determined by calculation or experiment.

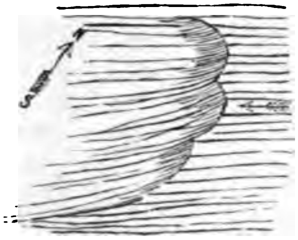
NEW INDEX OF THE DIRECTION OF MOTION.

The mark C, fig. 4, was copied from a granite *roche moutonneé*, at the fishing hamlet of Killarney, near some quartzite ranges named "Killarney Mountains." Striæ of this type show a multitude of minute cracks, extending laterally and curved so as to present their points forward in the direction of the glacial movements. Only large grooves and scratches show this peculiarity. It is a very convenient mode of determining the direction of the motion, for the pressure of the boulders which made the scratches as they moved forward, caused the transverse crevices to present their concave sides always forward. It is well known to engineers that in brittle substances the forms assumed by fracture vary with velocity of the impact, so that there is probably a time relation involved here also, which would make it possible to determine the approximate velocity of the ice which carried the boulders. Such a calculation, if based upon carefully repeated experiments, might prove an important contribution to our scanty knowledge of the Drift Period.

SCOOP-MARKS.

These are singular phenomena, and very difficult of explanation. They are of two varieties, the striated and the unstriated. Fig. 5 is a diagram intended to illustrate a typical form of the striated variety. The marks consist of shallow, elongated excavations, or troughs, which may be many feet in width. They run nearly in the direction of the general striation of the locality, and look as though a huge flour-scoop had been inserted into the rock and had cut out enough of its substance to make a smooth and rather shallow concave channel. The end toward the east or northeast, from whence the drift action came, is abrubt, sharply defined, and, although the angle of junction with the general surface is obtuse, yet this line of junction is a sharp and clearly-cut edge, and not a gradual sloping or rounding into the general level. The interior of the concavity is well striated in the direction of its own length, but the scratches are never continuous with those of the general surface northeast of the head of the scoop-mark; and conversely the striæ of the general glaciated surface are all cut off abruptly at the head of the scoop, and never descend at all into it.

Fig. 5.

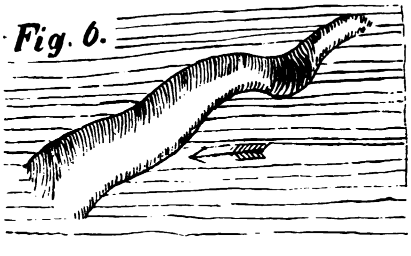


The tail of the channel grows shallower as it runs west or southwestward, and its thin extremity merges imperceptibly into the glaciated surrounding surface.

A few of the scoop-marks are nearly flat in contour, and are only recognizable where they cut abruptly through at an obtuse angle into the general face of the rocks. The interpretation of these anomalous scoop-marks is somewhat perplexing. At least, after considerable study of them, I am quite unable to frame a plausible theory of their origin other than the general one, that ice was the agent.

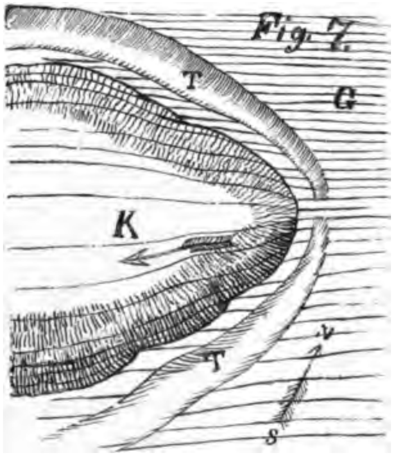
The unstriated scoop-marks differ considerably from the others in form, and on the average are smaller, seldom exceeding two feet in breadth. There are no glacial markings in their smooth but unpolished concavities.

Fig. 6.



Whether they never contained any striations, or whether the markings have been erased by sand and water driven through them before the Drift Period closed, is not easily determined. These channels generally are crooked, without obvious reason (see Fig. 6), and are narrowest at the end toward the northeast, from which direction the drift came. Toward the opposite extremity they grow wider and more shallow, disappearing finally and vaguely into the general ice-marked surface of the locality. The specimen shown in fig. 6 is, perhaps, six feet long, sunk in granite, without any crevice, vein or visible irregularity in the rock face to account for its excavation at that spot. These channels often differ pretty widely in direction from the adjacent striation, and the end nearest the northeast commences as a rounded depression, without the clear-cut edge presented by the striated scoop-marks. The darkly shaded spot in fig. 6 was deeper than the rest, as if from a species of "pothole" action.

Most of the striated scoop-marks are not independent phenomena, like fig. 6, but evidently are appendages to adjacent knobs and projections of rock. The type of such cases is represented in fig. 7, which is a diagram of the plan of numerous specimens seen along the eastern shore from Killarney to Parry Sound, a distance of about one hundred miles. K is a boss or knob of rock projecting above the general glaciated surface in an oval form, in fact a *roche moutonnée*. The specimen in fig. 7 is about four feet high, fifteen feet wide and thirty long, but the sizes of others vary without any obvious rule. The observed specimens are mostly in gneiss. The horizontal lines in the diagram show the general direction of the striation in the locality — nearly west-southwest as shown by the arrow. It will be seen that as the striæ approach and rise upon the surface of the knob they are deflected to the right and left, and sweep over it in an oblique course. This sort of curved deflection, partly over and partly around obstacles, is common to the whole coast, so that in many places almost all the striæ are curved by the influence of the knobby surfaces of the gneiss and quartzite.



T T are two unstriated scoop-marks, having a length of about ten feet and a width of twelve inches. They begin vaguely near to each other, but not in contact, close to the northeast end of the knob, and rapidly deepen to six inches or more as they curve about its two sides, after which they grow wider and more shallow until they become lost in the general glaciation along the sides of the rocky buttress. There are no striæ in these concavities, and their inner borders do not touch the base of the knob, but keep a foot or more away from it, leaving a narrow strip of level striated rock between the margins of the troughs and the eminence.

In a multitude of cases, just as in this one, it is sufficiently clear that the resistance offered by knobs of rock to the progress of the drift agencies in some way determined the presence and direction of these scoop-marks.

The great belt of fifty-two thousand islands, above referred to, varies from three to fifteen miles in width, and is about two hundred and fifty miles long. Beginning at the Ste. Marie river, it first outlines the north channel by the great Manitoulin group, and thence passing southeast through Frazer Bay, continues along the whole east coast of Georgian Bay and terminates near Collingwood.

Near the mainland, the islands are mostly metamorphic, with a very distorted stratification, but a few of those on the lakeward border of the belt are of Silurian limestone, with the strata dipping gently away from the nearest metamorphic hills.

This almost untrodden solitude, which has lain forgotten by the crowds of summer pleasure-seekers, is well worthy of a visit by the lover of nature. The magnificent panoramas of the island belt, as viewed from the summit of the LaCloche and Killarney ranges, are unique, and in themselves well worth the journey to the region. Fortunately, they are as yet almost unknown to sight-seers, and still remain in their original freshness and silence.

NO. 6 EAST SIXTEENTH STREET,
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BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES.

LIST OF BATRACHIA AND REPTILIA

OF

ILLINOIS.

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BY N. S. DAVIS, Jr., AND F. L. RICE.

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CHICAGO ACADEMY OF SCIENCES.

LIST OF BATRACHIA AND REPTILIA OF ILLINOIS.

BY N. S. DAVIS, JR., AND F. L. RICE.

The greater part of the following list was prepared for publication in 1876. The facts were collected by the authors and Mr. E. W. Nelson, to whom belongs equal credit in preparing the larger portion of the list. Since then, however, many additions have been made. A considerable number of species noticed below have not before been recorded as coming from this section of the country. There are quite a number also that, from their known distribution, we may expect to find in Illinois, but they have been excluded from the present list, as no well authenticated specimens from the State have come under the authors' notice. We wish to express thanks especially to Mr. Robert Ridgeway, Dr. P. R. Hoy, Prof. F. Stein and Dr. Schenck, for local lists which they have furnished us. The present list includes species and sub-species of—

Ophidia	**54**
Lacertilia	**6**
Testudinata	**14**
Total Reptilia	**74**
Trachystomata	**1**
Proteida	**1**
Caducibranchiata	**17**
Anoura	**13**
Total Batrachia	**32**
Total Reptilia and Batrachia	**106**

From this it is seen that nearly one-third of all the Reptilia and Batrachia of the United States are included in the fauna of Illinois.

MCZ. 1,403

BATRACHIA OF ILLINOIS.

TRACHYSTOMATA.

SIRENIDÆ.

1. *Siren lacertina*, Linn. Great Siren. Found throughout the Austroriparian region. A specimen in the collection of the Northwestern University was obtained in Northern Illinois.

PROTEIDA.

PROTEIDÆ.

2. *Necturus lateralis*, Say. Mud-puppy or Water-dog. Exceedingly abundant in Lake Michigan; found also in the Mississippi and other rivers throughout the State.

CADUCIBRANCHIATA.

MENOPOMIDÆ.

3. *Menopoma allegheniense*, Harl. Hellbender. Found in the Mississippi and its tributaries.

AMBLYSTOMIDÆ.

4. *Amblystoma talpoideum*, Holb. Mole Salamander. Found in the extreme Southern portion of the State.
5. *Amblystoma opacum*, Graven. Opaque Salamander. Abundant throughout the State.
6. *Amblystoma punctatum*, Linn. Large Spotted Salamander. Common in all parts of the State.
7. *Amblystoma tigrinum*, Green. Tiger Salamander. Exceedingly abundant everywhere.
8. *Amblystoma jeffersonianum*, Gr. sub-sp. *laterale*, Hall. Jefferson's Salamander. Found in the extreme Northern portion of the State.
9. *Amblystoma jeffersonianum*, Gr. sub-sp. *platineum*, Cope. A specimen in the collection of the Smithsonian Institution extends the Western range of this sub-species into Illinois.

PLETHODONTIDÆ.

10. *Hemidactylium scutatum*, Schl. Four-toed Salamander. Found throughout the State.
11. *Plethodon cinereus*, Gr. sub-sp. *cinereus*. Gr. Red-backed Salamander.

12. *Plethodon cinereus*, Gr. sub-sp. *erythronotus*. Gr. Both sub-species of this species are found in all parts of the State.
13. *Plethodon glutinosus*, Gr. Viscid Salamander. Common throughout the State.
14. *Spelerpes bilineatus*, Gr. Two-striped Salamander. Found throughout the State.
15. *Spelerper longicaudus*, Gr. Cave Salamander. From all parts of the State.
16. *Spelerpes ruber*, Daud.; sub-sp. *ruber*, Daud. Red Triton. Found throughout the State.

DESMOGNATHIDÆ.

17. *Desmognathus fusca*, Raf.; sub-sp. *fusca*, Raf. Dusky Salamander. Found in all portions of the State.
18. *Desmognathus nigra*, Gr. Black Salamander. A specimen in the collection of the Smithsonian Institution was found in Cook Co., Illinois.

PLEURODELIDÆ.

19. *Diemyctylus miniatus*, Raf.; sub-sp. *miniatus*, Raf. Red Evet. Common throughout the State.
20. *Diemyctylus miniatus*, Raf.; sub-sp. *viridescens*, Raf. Spotted Evet. Common in all parts of the State.

ANOURA.

BUFONIDÆ.

21. *Bufo lentiginosus*, Shaw; sub-sp. *americanus*, Le Conte. Common toad. Exceedingly abundant everywhere.

ENGYSTOMIDÆ.

22. *Engystoma carolinense*, Holb. Found in the extreme Southern part of the State.

HYLIDÆ.

23. *Acris gryllus*, Le C.; sub-sp. *gryllus*, Le C. Cricket Frog. From Southern Illinois.
24. *Acris gryllus*, Le C.; sub-sp. *crepitans*, Bd. Northern Cricket Frog. From the central and Northern part of the State.
25. *Chorophilus triseriatus*, Wied.; sub-sp. *triseriatus*, Wied. Tree Frog. Abundant in the Northern portion of the State.
26. *Hyla squirella*, Daud. Squirrel Frog. From Southern Illinois.

27. *Hyla pickeringi*, Holb. Pickering's Tree Toad. Not uncommon in the Northern portion of the State.
28. *Hyla versicolor*, Le C. Common Tree Toad. Abundant throughout the State.

RANIDÆ.

29. *Rana halecina*, Kal. Common Frog. Exceedingly abundant in all parts of the State. If the sub-species *halecina* and *berlandieri* are good, they are both found in the State.
30. *Rana palustris*, Le C. Pickerel Frog. Common throughout the State.
31. *Rana clamitans*, Merr. Green or Spring Frog. Abundant throughout the State.
32. *Rana catesbiana*, Shaw. Bull Frog. Common everywhere in the State.
33. *Rana temporaria*, Linn; sub-sp. *silvatica*, Le C. Found in all portions of the State. Abundant in the Northern part.
34. *Rana areolata*, B. & G.; sub-sp. *circulosa*. Ringed Frog. Specimens in the Smithsonian collections were obtained by Robert Kennicott in Northern Illinois.

REPTILIA OF ILLINOIS.

OPHIDIA.

CROTALIDÆ.

1. *Crotalus horridus*, Linn. Banded or Northern Rattle Snake. Found throughout the State. Abundant in certain localities.
2. *Caudisona tergemina*, Say. Massassauga. Prairie Rattle Snake. Found in all portions of the State except "the heavily timbered regions of the South."* Formerly abundant in the Northern portion, but less common at present.
3. *Ancistrodon piscivorus*, Lac.; sub-sp. *piscivorus*, Lac. Water Moccasin. Found in the Southern part of the State.
4. *Ancistrodon contortrix*, Linn. Copper-head. Cotton-mouth. Found occasionally in all parts of the State.

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*Fide Kennicott. List of Rep. and Batr. of Cook Co., 1853. Transactions of Illinois Agricultural Society.

COLUBRIDÆ.

5. *Carphophiops helenæ*, Kenn. Helen Tennison's Snake. From Southern Illinois.
6. *Carphophiops amœnus*, Say. Ground Snake. Found throughout the State, but not abundant.
7. *Carphophiops vermis*, Kenn. Worm Snake. From the Southern portion.
8. *Virginia valeriæ*, B. & G. Valeria Blaney's Snake. Southern Illinois.
9. *Virginia elegans*, Kenn. Kennicott's Brown Snake. Southern Illinois.
10. *Haldea striatula*, Linn. Brown Snake. From the Southern portions of the State.
11. *Abastor erythrogramus*, Daud. Red-lined Snake. From Southern Illinois.
12. *Farancia abacura*, Holb. Red-bellied Horn Snake. Found in Southern Illinois.
13. *Osceola elapsoidea*, Holb. Scarlet Snake. Southern Illinois.
14. *Ophibolus doliatus*, Linn; sub-sp. *coccineus*, Schl. Red King Snake. Southern Illinois.
15. *Ophibolus doliatus*, Linn; sub-sp. *doliatus*, Linn. Corn Snake. Southern part of the State.
16. *Ophibolus doliatus*, Linn; var. *triangulus*, Borè. Milk Snake or Spotted Adder. Abundant throughout the State.
17. *Ophibolus getulus*, Linn; var. *Sayi*,* Holb. King Snake. Found in all parts of the State.
18. *Ophibolus rhombomaculatus*, Holb. Southern Illinois.
19. *Ophibolus calligaster*, Say. Kennicott's Chain Snake. Southern part of State.
20. *Diadophis punctatus*, Linn; sub-sp. *punctatus*, Linn. Ring-necked Snake. Throughout the State. Not common.
21. *Diadophis punctatus*, Linn; sub-sp. *amabilis*, B. & G. Southern Illinois.
22. *Diadophis arnyi*, Kenn. Arny's Ring-necked Snake. Southern Illinois.
23. *Cyclophis vernalis*, De K. Green or Grass Snake. Abundant in the Northern part of the State; rare in the Southern.
24. *Cyclophis æstivus*, Linn. Summer Green Snake. From Southern Illinois.
25. *Coluber emoryi*, B. & G. Emory's Racer. Found in the Southern portion of the State.
26. *Coluber lindheimerii*, B. & G. Southern Illinois.

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*This species has been taken in Wisconsin by Dr. P. R. Hoy, of Racine.

27. *Coluber vulpinus*, B. & G. Fox Snake. Common in Northern Illinois; propably found throughout the State.
28. *Coluber obsoletus*, Say; sub-sp. *obsoletus*, Say. Pilot Snake. Throughout the State.
29. *Coluber obsoletus*, Say; sub-sp. *confinis*, B. & G. Racer. Southern Illinois.
30. *Coluber guttatus*, Linn. In the Smithsonian collection there is a specimen from Mt. Carmel, Ill.
31. *Pityophis sayi*, Schl.; sub-sp. *sayi*, Schl. Western Pine Snake. Found throughout the State. Not common.
32. *Bascanion constrictor*, Linn; sub-sp. *constrictor*, Linn. Black Snake. Blue Racer. Abundant throughout the State.
33. *Eutænia saurita*, Linn. Riband Snake. Swift Garter Snake. Throughout the State.
34. *Eutænia faireyi*, B. & G. Fairies' Garter Snake. Occurs throughout the State.
35. *Eutænia proxima*, Say. Say's Garter Snake. Found in all parts of the State; common in the Northern portion.
36. *Eutænia radix*, B. & G. Hoy's Garter Snake. Very abundant in the Northern part of the State.
37. *Eutænia vagrans*, B. & G.; sub-sp. *vagrans*, B. & G. Spotted Riband Snake. A typical specimen of this species was collected near Chicago by Mr. E. W. Nelson in 1874.
38. *Eutænia sirtalis*, Linn; sub-sp. *dorsalis*, B. & G. Common Striped Snake. Abundant in all parts of the State.
39. *Eutænia sirtalis*, Linn; sub-sp. *sirtalis*, Linn. Common Garter Snake. Exceedingly common throughout the State.
40. *Etuænia sirtalis*, Linn; sub-sp. *parietalis*, Say. Red-spotted Garter Snake. "Occurs plentifully in the Wabash Valley."* Has also been taken in the central portion of the State.
41. *Eutænia sirtalis*, Linn; sub-sp. *obscura*, Cope. Common in Northern Illinois.
42. *Storeria occipitomaculata*, Storer. Red-bellied Snake. Common in all parts of the State.
43. *Storeria dekayi*, Holb. De Kay's Brown Snake. Found throughout the State; abundant in the Northern portion.
44. *Tropidoclonium kirtlandi*, Kenn. Cora Kennicott's Snake. Rare in Northern Illinois; abundant in central.
45. *Tropidonotus grahami*, B. & G. Graham's Snake. Found throughout the State; less abundant than formerly in the Northern portion.
46. *Tropidonotus leberis*, Linn. Leather Snake. Occurs throughout the State; abundant in the Northern portion.

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*Fide R. Ridgeway.

47. *Tropidonotus fasciatus*, Linn. Fasciated Water Snake. Southern Illinois.
48. *Tropidonotus sipedon*, Linn; sub-sp. *sipedon*, Linn. Water Snake. Abundant in all parts of the State.
49. *Tropidonotus sipedon*, Linn; sub-sp. *woodhousei*, B. & G. Found throughout the State.
50. *Tropidonotus sipedon*, Linn; sub-sp. *erythrogaster*, Sh. Red-bellied Water Snake. Found throughout the State.
51. *Tropidonotus rhombifer*, Hall. Throughout the State.
52. *Tropidonotus cyclopium*, D. & B. Southern Illinois.
53. *Heterodon platyrhinus*, Latr. Spreading Adder. Abundant in all parts of the State.
54. *Heterodon simus*, Linn; sub-sp. *simus*, Linn. Hog-nosed Snake. Occurs throughout the State.[*]

LACERTILIA.

SCINCIDÆ.

1. *Oligosoma laterale*, Say. Ground Lizard. Southern Illinois.
2. *Eumeces fasciatus*, Linn. Blue-tailed Lizard. Found throughout the State; especially common in the Southern portion.
3. *Eumeces obsoletus*, B. & G. Central and Southern Illinois.

TEIDÆ.

4. *Cnemidophorus sexlineatus*, Linn. Six-lined Lizard. Found in all parts of the State, and extends Northward into Wisconsin.[†]

ANGUIDÆ.

5. *Opheosaurus ventralis*, Daud. Glass Snake. Found throughout the State. Abundant in the central part; formerly common in the Northern, but rare at present. Has been taken in Southern Wisconsin.[‡]

IGUANIDÆ.

6. *Sceloporus undulatus*, Harl.; sub-sp. *undulatus*, Harl. Swift Lizard. Taken throughout the State; abundant in some localities.

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[*] Dr. P. R. Hoy has taken this species in Western Wisconsin.

[†] Wisconsin. Fide Dr. P. R. Hoy.

[‡] Wisconsin. Fide Dr. P. R. Hoy.

TESTUDINATA.

TRIONYCHIDÆ.

1. *Amyda mutica*, Les. Leathery Turtle. Found in the Mississippi other rivers of the State. Has been taken in Lake Michigan.
2. *Aspidonectes spinifer*, Les. Common Soft-shelled Turtle. Found Lake Michigan; abundant in many of the rivers of the State.

CHELYDRIDÆ.

3. *Chelydra serpentina*, Linn. Common Snapping Turtle. Very com in all localities.
4. *Macrochelys lacertina*, Schw. Alligator, or Mississippi Snap Southern Illinois. Has been taken in the Mississippi as North as Wisconsin.*

CINOSTERNIDÆ.

5. *Aromochelys odoratus*, Latr. Musk Turtle. Stink Pot. Through the State.
6. *Aromochelys carinatus*, Gray. Has been taken as far north as L County.

EMYDIDÆ.

7. *Pseudemys hieroglyphica*, Holb. Southern Illinois.
8. *Pseudemys troosti*, Holb. Yellow-bellied Terrapin. Southern part the State.
9. *Pseudemys elegans*, Wied. Southern Illinois.
10. *Malacoclemmys geographicus*, Les. Map Turtle. Found throughout State.
11. *Malacoclemmys pseudo-geographicus*, Holb. Le Sueur's Map Tur Found in all parts of the State.
12. *Chrysemys picta*, Herm. Painted Turtle. Found throughout State; abundant in the Northern portion.
13. *Emys meleagris*, Shaw. Blanding's Turtle. Abundant in North Illinois.
14. *Cistudo clausa*, Gm. Common Box Turtle. Throughout the Stat

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*Wisconsin. Fide Dr. P. R. Hoy.

Vol. I. *No. V.*

BULLETIN

—OF THE—

CHICAGO ACADEMY OF SCIENCES.

A PAPER ON

The Northern Pitcher-Plant or the Side-saddle Flower. Sarracenia purpurea, L.

By W. K. HIGLEY.

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BULLETIN

—OF THE—

CHICAGO ACADEMY OF SCIENCES.

The Northern Pitcher Plant or the Side-saddle Flower, Sarracenia purpurea, L.

By W. K. HIGLEY, Seminary, Lake Geneva, Wisconsin.

That insects are of great use in the vegetable economy is a subject of much interest to many scientific minds of the present day, causing many investigations resulting in experiments that are leading us into a deeper and truer knowledge of the physiology of plants.

These investigations are transforming many theories into facts; many mere fancies into realities; many of the so-called "freaks of nature," of the older writers, into useful adaptations for aiding in the development of the plant. It is now obvious, even to the slack and unscientific observer of nature's laws and methods of work, that the insect world is necessary for the proper growth and propagation of many species belonging to the vegetable kingdom.

It is well known to the intelligent agriculturist that many of the plants used in our economy could not even mature their seeds unless aided by insects, notably the hive bees. The beautiful orchid family is a grand illustration of the usefulness of insects in fertilization. Dr. Charles Darwin has shown that each part of the flower is adapted to this end. It seems as if, in this family, nature truly abhors self-fertilization and in some species, though giving the plant all the parts of a hermaphrodite, yet arranging them so that only an insect can bring about the proper relations for propagation. Our melon, pumpkin, squash, cucumber and gourd plants are also worthy of note in this connection. "The flowers" of these "are each furnished with a long or rather deep corolla and the plants often lie flat on the ground where the leaves cover the flowers from the action of the wind. Bees and other insects are the necessary agents in crossing the flowers", for they are either diœcious or monœcious, "and to them we are indebted as one of the links in the chain which affords all our gourd-like fruits."

To this division of Entomophilous species belongs the plant under consideration in this paper. All the species of the genus Sarracenia are constructed in such a manner that in fertilization they are absolutely helpless without the aid

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of insects. The large umbrella-like expansion of the style, which is stigmatic at the termination of the fire rays, completely hides the stamens which are decidedly below it and shielded from the wind.

A still more peculiar use of insects to the vegetable world is that of a food and many plants are specially fitted for catching and useing the material of their bodies for nourishment.

Perhaps the most striking of all these plants are the pitcher-plants, some of which throw out a honeyed secretion which, trickling down the wing of the pitcher, forms a baited pathway to attract the unwary insect to the inside of the pitcher.

The genus Sarracenia, to which the plant under consideration belongs, is one of the three genera of the order Sarraceniaceæ. The species of all the genera are natives of America and chiefly of the United States, the genus Heliamphora being a native of Venezuela. Mr. Sereno Watson * makes the following enumeration of the species of the other two genera, Darlingtonia and Sarracenia:

Darlingtonia Californica, Torr.
Sarracenia Drummondii.
" flava, L.
" psittacina, Mx.
" purpurea, L.
" nigra, Walt.
" Sweetii, D C.
" undulata, Denie.
" variolaris, Mx.

All the species have root-leaves and excepting the genus Heliamphora, have terminal scapes bearing a single flower. The exception has a scape bearing a few flowered raceme. The leaves are all hollow and more or less pitcher-shaped, with a hood at the upper part and a wing, that is often very broad, upon one side.

As to their position in classification, this family† quite closely resembles the poppy family (Papaveraceæ,) on the one hand, and the water-lily family (Nymphæaceæ) on the other. It is related to the former by the character of its petals, numerous stamens and seeds, capsular fruit, copious albumen, etc. It is connected with the latter by nearly the same characters,‡ and also by having all the leaves from the root, a one-flowered scape and more or less aquatic habits. The poppy family differs in habits, juices, in having but two or three sepals and a one-celled ovary. The water-lily family differs in having, usually, numerous petals, in the attachment of the seeds and the sessil stigmas.

By certain analogies the pitcher-plants are closely related to the sundew family (Droseraceæ), and the Asiatic pitcher-plant family (Nepenthaceæ).

A microscopical study of the minute structure of the families mentioned not only confirms the close relationship existing between them but also adds new facts to those that appear from a study merely of the external characters of their representative species.§

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*Bibliographical Index to North America Botany, by Sereno Watson, Smithsonian Miscellaneous collections.

†General System of Botany, LeMaout, and Decaisne. p. 212.

‡The water-lily family in some of its forms has a definite number of stamens.

§Since the writing of this paper Mr. J. F. James has published a very interesting article on "How the Pitcher Plant got its Leaves." (American Naturalist Vol. xiv, p. 567.)

After tracing the apparent gradation of adaptability for taking insect food existing beween the species of the genera of Sarraceniaceæ from the less marked trap and imperfect

Our northern pitcher-plant is, perhaps, the one of greatest interest to the people of the Northern States.

It is by far the most common form of the genus extending in its range over the states east of the Mississippi and north from Florida far into the British Possessions. It is not so elaborate an insect catcher as some of the more southern forms which have already been spoken of as throwing out a honeyed lure which attracts numerous ants, an insect rarely found in our species.

The pitcher leaves (Ascidia) of the Side-saddle flower, as well as those of all the family, are evidently phyllodia. They have the parallel veination of petioles acting as blades and the edge is invaribly turned toward the sky. The hood may represent the blade of the leaf. The wing forms the greater part of the young leaf.

Inside these pitchers are found hairs, which cover more or less of the inner surface. Those which cover the hood continue to or a little beyond the junction with the tube. Following this area is a smooth surface which extends to near the point where the leaf begins to contract when a patch of less stiff hairs are met with. This time they extend into the narrower portion of the tube. All the hairs point downward.

The position and form of these hairs, especially those on the hood and upper part of the tube and in fact any that may be above the fluid, in the lower part of the leaf, would show that their function, in part at least, is to prevent the escape of any insect that may have entered the tube. The hairs in the lower part of the tube probably act, to some extent, as absorbents of the nitrogeneous matter decaying within the leaf. Some acute observers claim that at the end of each hair there is a minute opening, thus allowing the nitrogeneous fluid to pass directly into the apical cell of the hair. This does not seem to be the case but instead the wall surrounding the entire cell is very thin. These hairs are simple trichomes, that is they are rather cells than organs. Unlike the tentacles of the sundew, in no case do the spiral bundles enter their tissue. I am inclined to believe that these cellular hairs serve more than one purpose in the economy of the plant.

A study of the structure and physiology of the whole family shows that all the forms need a great deal of absorbing surface for there seems to be a lack of stomata. The tissue of the leaf is almost constantly gorged with a large supply of nourishment consisting, evidently, of absorbed nitrogeneous matter, and

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pitcher of Heliamphora through the genus Sarracenia to the remarkable trap pitcher of Darlingtonia with its attractive appendages, digestive fluid and sweet lure, Mr. James says: "Scarcely any of the steps showing the progress are needed to complete the line of development. It can be traced directly from Heliamphora to Darlingtonia, and it is only necessary to have an ancestral form from which to start to have a complete pedigree. It seems probable that the water-lily family and the pitcher-plant family had a single ancestor in common. This ancestor was aquatic, or least an inhabitant of swampy places. It had small, probably peltate, perhaps reniform leaves, and these had hollow petioles. The inner space was lined with hairs as are now the inner surfaces of the stems of Nymphæa and its allies; it had a four or five parted flower, with many stamens and a broad stigma. From such an ancestor came two or three branches. One of these developed into plants having an aquatic habit, large leaves and long petioles, and peduncles like those which are found at present in the water-lilies. The other branch diverged to form plants living in boggy or swampy grounds, with pitcher-like leaves whose insectivorous proclivities were developed later on."

Mr. James suggests that these proclivities were developed by a true process of natural selection. The more or less saucer-like peltate leaves may possibly have held some water in which insects were drowned. This fluid, by standing causing the decay of the blade at the insertion of the petiole, found its way into the hollow petiole and finally by absorption of the nitrogenous matter the plants gained nourishment that could be used in its growth. This adaptation being of use to the plant might lead, in the next generation, to leaves better fitted for taking food in this manner. This in course of time would give rise to a generation of petioles peculiarly adapted to catching water and insects by being pitcher-like in form. The blade no longer needed for absorption would become a mere rudiment and then would follow the further process of perfecting traced by Mr. James in Sarraceniaceæ.

needs a great extent of surface exposed to the air for the purpose of absorption in carrying on the functions of assimilation and metastasis. In support of this there is considerable evidence, the most important of which is the fact that many of these hairs, especially those on the hood, contain chlorophyl. From a study of marked leaves through the whole season I am led to believe that some of the hairs are absorbed as the leaf grows old. This would indicate that as the function of the leaf are lessened the extent of absorbing surface is reduced.

When the leaf has apparently nearly stopped absorbing the moisture from the tube it may still be an active insect trap. At this time an especially strong odor is given off from the decaying mass of insects. It would seem that the insects caught now could be of no use except as a fertilizer, when by the decay of the leaves, all this mass of decomposing nitrogeneous matter is deposited around the roots of the plant. The decaying material, moreover, seems to hasten the decay of the leaf, as its vitality is lessened by the advancing season.

It is noticeable that there are many insects around the leaves just at twilight or when the sky is overcast with heavy clouds. Remains of nocturnal insects are also very common in the mascerating mass. This seems to indicate that flies and other insects seek the hollow leaves in which to retreat during the hours when they are naturally at rest. It is a fact that insects seek retreats of this kind.

True to the habits of the spiders to seek those places for their homes that flies frequent, there is one that makes its home at the top of the leaves spinning its web so that it nearly covers the whole opening. In each case that I have observed it is the same species but whether it always seeks the pitchers, I cannot state.

An insect lighting upon the leaf starts immediately to walk toward the inside. It seldom stops till the smooth place is reached where sooner or later it loses its foot-hold and falls. In some cases they try to fly upward from the bottom of the pitchers. In but one case have I seen an insect escape in this manner. This, a beetle, obtained its freedom by flying from one side of the tube to the other till the opening was reached.

A slight secretion has been observed by many near the opening of the pitcher. This seemingly has but little power to attract insects, though at times it is quite copious.

Mr. Joseph Jackson says,* "While collecting a few specimens of S. purpurea, L., I was surprised on drawing aside the petals to look at the stamens to see the whole cavity formed by the petals and the peltate expansion of the style filled with flies as large as the common house fly, all busy as could be eating the pollen, of which scarcely a grain could be seen. I counted fourteen flies in one flower. They were in no hurry to vacate the premises. There was a shower coming up at the time, but they were evidently there for food. Nearly every plant examined was filled in the same way."

Mr. J. F. James suggests† that perhaps "there is something in the pollen, or in some secretion of the flower which has the effect of stupefying or intoxicating the insect and that then they might easily be shaken from the flower, by the wind, into the open mouths of the rosette of leaves below."

My observations differ somewhat as to the usefulness of these insect visits to the flowers. There are two or three species of Diptera found in the manner described. They are evidently attracted to the flower by some property of the pollen or a secretion of some other part of the flower, but it would seem mainly for the purpose of aiding in fertilization for a lense reveals the fact that pollen is quite freely scattered over their backs. Moreover, these plants flower during the latter part of May and first of June, while insects are caught during the months of May, June, July and August. Though without question some of the flies from the flowers do eventually find their way into the pitchers underneath, yet these species are not nearly so common in the decomposing mass as some other species. Some time was spent in taking notes as to the effects of this food upon the flies but without any results showing stupefaction.

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*Bot. Gazette Vol. VI. No. 7.

†Amer. Nat. Vol. XVII, p. 284.

The great question is: What purpose do the decaying remains in the bottom of the tube serve in the economy of the plant? In order to decide this question it will be necessary to know the chemical nature of the fluid found in the pitchers. Several chemical analyses were made under as widely different conditions as a limited region of country would allow. As a result of the examination of over 800 leaves I find that none contained any fluid before they had opened. These were collected from several localities. After opening there is no fluid till after the first rain except in a few cases when there has been a heavy dew.

The following table is the result of a series of twenty-five chemical analyses, selected from one hundred the total number made, and shows approximately the composition of the fluid before it contained any insects. The sediment is the result of evaporation:

Number.	Condition of the Soil.	Time in days since leaf opened.*	Time in days since rain had fallen.	Color of Fluid.	Dri'd Residue from Evaporation†		Reaction.	Inorganic Substances.	Remarks.
					Organic.‖	Inorganic			
1	Swamp	5	1	Clear...	3...	2....	Slightly acid	Ammonium, ‡Potassium, Carbonic Acid...............	
2	Swamp	8	4	Slightly Yellow..	9...	3....	Acid....	Ammonium, Lime, Potassium, Carbonic Acid.........	Under trees in edge of swamp.
3	Swamp	15	3	Yellow..	11...	4....	Acid....	Ammonium, Potassium, Sodium, Hydrochloric, Sulphuric and Carbonic Acids.	Under trees in edge of swamp.
4	Dry	20	18	Clear...	14...	5....	Acid....	Ammonium, Potassium, Lime, Sodium, Magnesium, Carbonic, Hydrochloric, and Sulphuric Acids.	At edge of woods in soil containing much lime.
5	Moist	6	2	Clear...	6...	3....	Acid....	Ammonium, Lime, Potassium, Hydrochloric and Carbonic Acids.	Not far from the last.
6	Wet	10	4	Tinged..	8...	3....	Acid....	Ammonium, Potassium, Sodium, Sulphuric, Hydrochloric and Carbonic Acids.	
7	Wet	12	8	Tinged..	10...	4....	Acid....	Ammonium, Potassium, Lime, Aluminium, Sulphuric and Carbonic Acids.	Near dusty road and under trees.
8	Swamp	15	14	Tinged.	20...	5....	Acid....	Ammonium, Potassium, Lime, Aluminium, Iron, Sulphuric and Carbonic Acids.	In neighborhood of several iron springs, near a road and under trees.
9	Swamp	11	5	Yellow..	7...	3....	Acid....	Ammonium. Lime, Potassium, Hydrochloric and Carbonic Acids.	In deep grass.
10	Swamp	7	4	Clear...	4...	1....	Acid....	Ammonium, Lime, Potassium, Hydrochloric, and Carbonic Acids.	In deep grass.
11	Swamp	7	4	Clear...	5...	1....	Nearly.. neutral.	Ammonium, Lime, Potassium, Sodium, Hydrochloric, and Carbonic Acids.	Same plant as last.
12	Swamp	14	6	Dirty...	13...	4....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Aluminium, Carbonic, Hydrochloric and Sulphuric Acids.	In grass near woods and dusty road.
13	Swamp	9	5	Dirty...	7...	2....	Acid....	Ammonium, Lime, Potassium. Iron, Aluminium, Sulphuric and Carbonic Acids.	In grass near woods and dusty road.
14	Swamp	10	6	Quite Clear...	4...	1....	Nearly.. neutral.	Ammonium. Potassium, Lime, Sodium, Hydrochloric and Carbonic Acids.	In open swamp near road.
15	Swamp	5	2	Quite... Clear...	2...	1....	Nearly.. neutral	Ammonium, Potassium, Lime, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
16	Wet...	8	4	Yellow..	6...	3....	Slightly acid	Ammonium. Potassium,Lime, Sodium,Magnesium, Carbonic and Hydrochloric Acids.	Under grass.
17	Swamp	3	1	Clear...	2...	2....	Slightly acid	Ammonium, Potassium, Carbonic Acids.	Open swamp.
18	Dry...	8	5	Yellow..	4...	4....	Slightly acid	Aluminium, Iron, Potassium, Sodium, Ammonium. Silica, Sulphuric, Hydrochloric and Carbonic Acids.	Side of dusty road and in the shade.

19	Dry...	2	1	Clear	4....	2....	Nearly neutral	Ammonium, Aluminium, Potassium, Sulphuric, Hydrochloric and Carbonic Acids.	Side of dusty road and in the shade.
20	Moist	11	5	Yellow	5....	3....	Slightly acid	Ammonium, Potassium, Lime, Iron, Hydrochloric and Carbonic Acids.	In open swamp near iron springs.
21	Moist	13	5	Yellow	7....	3....	Slightly acid	Ammonium, Potassium, Lime, Hydrochloric and Carbonic Acids.	Under trees.
22	Wet	3	1	Clear	2....	2....	Slightly acid	Ammonium, Lime, Carbonic Acid.	Open swamp.
23	Swamp	5	2	Clear	4....	2....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
24	Swamp	7	2	Clear	6....	2....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
25	Swamp	8	3	Clear	5....	1....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.

*This has reference to the time since the leaf was in such a condition that rain could easily enter it.

†Number of parts in 1000.

‡It is probable that in each case when ammonium is reported, nitric acid was combined with it (N H 4, N O 3) but there being but a trace it could not readily be found without much concentration.

‖The organic residue when examined with a microscope revealed the fact that it consisted, to a great extent, of pollen, various other vegetable structures, Infusoria, algæ and the like.

The following tables represent analyses made each month to test the condition of the liquid as the season advanced. The ten enumerated in each table were selected from one hundred analyses made from leaves picked the last day of the month. In each set the two extremes are given and the intermediate ones illustrated well the mean numbers of the complete series of one hundred. The amount of residue is expressed in parts per 1000:

MAY.

Number.	Condition of the soil.	Time in dy's since rain had fallen.	Color of Fluid.	Dried residue from evap'rat'n		Reaction.	Inorganic Substances.	Remarks.
				Organic.	Inorganic.			
1	Swamp	15	Yellow	60....	4......	Acid.	Ammonium, Potassium, Lime, Sodium, Magnesium, Carbonic and Hydrochloric Acids.	In grass and protected.
2	Quite dry	23	Wine..	100....	8......		Ammonium, Potassium, Sodium, Aluminium, Iron, Sulphuric, Carbonic and Hydrochloric Acids.	Very near dusty road.
3	Moist.	5	Dirty..	108....	5......		Same as No. I.	
4	Swamp	7	Dirty..	110....	4......		Same as No. 1.	Near edge of swamp but away from dust of roads.
5	Edg. of Swamp	5	Wine..	130....	6......		Ammonium, Potassium, Lime, Sodium, Magnesium, Iron, Hydrochloric and Carbonic Acids.	Near sandy hill-side.
6	Swamp	3	Yellow	68....	3......		Ammonium, Sodium, Potassium, Lime, Hydrochloric and Carbonic Acids.	
7	Swamp	1	Dark..	82....	2......		Same as No. 6.	Protected by deep grass.
8	Edg. of swamp	6	Dark..	110....	4......		Ammonium, Potassium, Lime, Magnesium, Aluminium Sulphuric, Hydrochloric, Carbonic Acids.	Near dry hill-side.
9	Dry...	6	Dirty..	105....	7.....		Same as No. 2.	Barren hill-side, clay soil.
10	Moist.	11	Wine..	115....	4......		Same as No. 6.	Near dry, grassy hill-side and nearly under a willow bush.

JUNE.

Number.	Condition of the soil.	Time in dy's since rain had fallen.	Color of Fluid.	Dried residue from evap'rat'n		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic.			
1	Swamp	5	Dirty..	120...	7....	ACID.	Ammonium. Potassium, Lime, Sodium Magnesium, Aluminium, Sulp'ric, Hydroch'ric, Carbonic Acids.	Near road.
2	Edg. of Swamp	7	Dirty..	132...	9.....		Same as No. 1, with Iron.	Near road and large iron springs.
3	Moist.	2	Wine..	162...	10.....		Same as No. 2.	Near iron springs.
4	Dry....	3	Dirty .	150...	9.....		Same as No. 3, with Silica.	Near dusty road and sandy hillside.
5	Dry....	1	Dirty..	142...	6.....		Same as No. 4.	Same.
6	Moist .	4	Dirty..	139...	13.....		Same as No. 5.	Same.
7	Swamp	6	Dirty..	157...	8.....		Same as No. 2.	Near dusty road.
8	Swamp	3	Dirty..	173...	6.....		Same as No. 1.	Near road and under trees.
9	Swamp	6	Dirty..	170...	5.....		Same as No. 2.	In swampy place made by iron springs.
10	Swamp	4	Dirty..	147...	6. ...		Same as No. 1.	

JULY.

Number.	Condition of the soil.	Time in d'ys since rain had fallen.	Color of Fluid.	Dr'd res'du from evaporation.		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic			
1	Swamp	3	Dirty.	137	6	Acid.	Ammonium. Potassium. Sodium. Lime, Magnesium, Hydrochloric and Carbonic Acids.	Remote from road but near barren spot.
2	Swamp	5		173	8		Same as No. 1, with Iron,	Similar place, but in swamp formed by iron springs.
3	Edg of swamp	11		195	12		Ammonium Potassium, Sodium. Lime. Magnesium Iron. Silica Alu'in'm. Hyd'ch'rc, Sulp'rc, Car'bc acids	Very near dusty road and sandy hill-side.
4	Swamp	15		200	7		Same as No. 3, without Iron.	
5	Dry. ..	11		195	11		Same as No. 3.	Same as No 3,
6	Swamp	15		203	6		Same as No. 1 with Silica.	In deep swamp, but where the sand could be blown in from a barren spot.
7	Edg. of swamp	15		207	9		Same as No. 2 with Silica.	Similar position to that of No. 6.
8	Swamp	9		187	6		Same as No. 7.	
9	Swamp	8		196	7		Same as No. 3, without Silica.	Near road but in very swampy place.
10	Swamp	9		205	9		Same as No. 3.	In very swampy place, but near very dusty clay road bed and under branches from tree.

AUGUST.

Number.	Condition of the soil.	Time in d ys since rain had fallen.	Color of Fluid.	Dr'd res'du' from evaporation		Reaction.	Inorganic Substances.	Remarks.
				Organic.	Inorganic			
1	Dry....	10	Dirty.	164	18	Acid.	Ammonium. Potassium Sodium Lime. Aluminium. Iron. Silica. Carbonic, Sulphuric, Hydrochl'ric Acids.	Near road and near field of sandy soil. Large proportion of silica. Prevailing winds toward the plant from the field.
2	Dry....	5		200	14		Same as No. 1.	A similar location. A large p. c. of silica.
3	Wet...	10		225	10		Same as No. 1.	A similar location but near edge of woods.
4	Wet...	15		205	8		Same as No. 1 without Silica, Aluminium or Sulphuric Acid.	Deep swamp.
5	Swamp	20		237	13		Same as No. 1 without Silica.	Near road and under tall grass and weeds.
6	Dry....	20		260	16		Same as No. 1.	In a damp but not very swampy place surrounded by barren sand-hills. Large proportion of silica.
7	Edg. of swamp	15		257	9		Same as No. 1 without Aluminium, Silica or Sulphuric Acid.	In deep swamp.
8	Moist .	5		245	12		Same as No. 1 without Silica.	Not near road but under trees.
9	Moist .	5		198	10		Same as No. 8.	In a tamarack swamp and under grass which held much dust.
10	Swamp	10		242	9		Same as No. 8.	

The oldest leaves to be found were in each case selected and it is thought that in all cases they were the growth of the season up to date. In preparation the leaf was cut open and the contents removed to a crucible, but in no case was the mass used unless of such a consistency that it would flow easily. The reaction was acid in each case but the degree of acidity increased each month and was very marked through July and August. To just what acid, if any particular one, the reaction was due in the liquid of the earlier pitchers is not certain, but in the two last months both Malic and Citric acids appeared, the former in greater abundance.

The analysis of the ash and the residue of the filtered and evaporated fluid was qualitative. The object being simply to see if there was any relation existing between the inorganic matter contained in the fluid and the surrounding soil, etc., it was not minute. In each case, where it was possible, the soil near by at all liable to get into the pitcher was analyzed. However, not all the inorganic salts could be accounted for as from the soil. Whenever it was evident that the inorganic matter was similar to the soil near the plant it is indicated in the tables under the head "remarks" by giving the character of the surrounding soil.

It seems highly probable that the first lot of insects merely decay after maceration in the water first collected in the pitchers and that this mass acts not only as a stimulant to further decay but also to render the liquid more capable of absorbing certain organic principles from the leaf, such as Malic acid, which aid in the preparation of the abundant supply of food for absorption by the leaf. Thus the first mass might be called a digestive excitant. There being no glands, the process of exciting the leaf to the secretion of an acid would be quite slow.

That this is the case, I feel assured by the fact that absorption evidently takes place much more rapidly during the last days of June and the months of July and August. It is then that much nutriment is needed and the cells are filled with matter. The large tubular cells in the structure of the lower part of the pitcher walls and in fact those extended downward into the root are at this time charged with matter, while earlier they are comparatively empty, though much nitrogenous matter has been in the leaves for several weeks.

By a set of experiments it was easily shown that the ammonia contained in the liquid, either having its source in the rain water brought to the plant, in the results of the decomposing remains of the insects, or in the absorption from the atmosphere was readily and quite rapidly absorbed by the leaf.

In these experiments it was assumed that but little would be absorbed by the liquid from the air, during the season of experiment, especially if it was a dry time. Such a time was therefore selected and the leaves so turned and propped that no rain could fall into them. The leaves marked were those that contained but few insect remains. Two in each case were examined from each plant. Great care was used that both should have the same age, amount of liquid and nearly the same amount of remains and especially that they should have as near the same size as possible.

One leaf was marked and treated as above while the fluid of the other was immediately tested for organic ammonia and the amount estimated. At the end of a week the marked leaves were picked, quickly examined and the fluid analyzed for organic ammonia. The fluid showed a decided decrease in each case, from the amount found in the one used in comparison. Though these analyses were perhaps quite far from sure in every detail yet the average difference on comparison, viz: sixty parts in one hundred, would indicate quite rapid absorption, for such an amount could not possibly be removed in any other way.

Associated with the remains of insects in these pitchers and apparently nearly always able to overcome the obstacles to escape, are a few other insects.

The first of these a moth *Xanthoptera semicrocea*, Gneu. which feeds upon the tissue of the leaves themselves, is not so common in the leaf of the side-saddle flower as in the more southern species.

There is another moth besides this which is more common. Though I have not been able to study it to any extent, yet from a casual observation I feel convinced that it is not the same species as the above though the larvæ of both are very much alike. It is possible that it may be a new variety.

The egg is lain within the tube, generally about the middle of the leaf, and fastened to the smooth surface by a web so that seemingly the egg might not only be secure but that also the larvæ might have a secure scaffolding upon which to stand as soon as hatched when it immediately covers the smooth surface with the same kind of web and is thus able to go wherever it wills. It is often the habit of this insect to close the mouth of the pitcher in the southern forms. In a few cases I found threads stretched across the opening of the hood but it is impossible to close the lips of the northern pitcher plant. "As the larvæ increases in size it frets the leaf within feeding on the parenchyma and leaving only the epidermis." Occasionally these larvæ are found dead in the bottom of the pitcher. They had apparently fallen into the liquid and drown

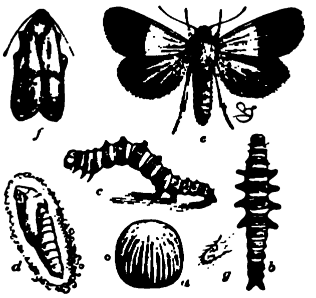
Another very common insect, even more common than the moth, is a *Sarcophaga sarraceniæ*, Riley. A dozen or more living larvæ are dropped in the tube by the fly where they feed upon the decaying mass of insect remains

As a rule but one larva matures, the others having been devoured by it.

The larva undergoes its metamorphosis in the ground at the base of the leaf. Its transformation is completed in about a week.

Dr. C. V. Riley, U. S. Entomologist, has kindly furnished me with very full descriptions and cuts of the moth, *X semicrocea*, Guen. and the fly *S. sarraceniæ* Riley.

These, with his permission, I append in full * for there are but few printed descriptions.



XANTHOPTERA SEMICROCEA.—*a*, egg, enlarged, the natural size indicated at side; *b*, *c*, larva, back and side views; *d*, chrysalis; *e* moth, normal form, with wings expanded; *f* pale variety, with wings closed; *g*, enlarged tubercle of larva

XANTHOPTERA SEMICROCEA Guen. Egg—Globular, slightly flattened at top and bottom; 0.02 inch in diameter. Color when mature, grayish, with about 35 ribs of a paler color, some of them anastomosing and all becoming fainter toward the crown, which is smooth.

Larva—Average length 0.8 inch. Thickest in the middle of the body, and having but three pairs of prolegs. Color deep crimson, or lake-red, the joints being deeply separated, and their borders, especially posteriorly, being white and strongly contrasting with the red. On each of joints 4, 5, 6 and 7 is a pair of more or less confluent, [illegible] patches, and a subdorsal, fleshy tubercle, the fore one [illegible] the longest, the others gradually diminishing in length. The other joints are each ornamented with about a dozen small, dark, conical tubercles, transversely arranged on 2 and 3, from a trapezoid to a square on 8, 9, 10 and 11, and on 12 in an opposite position to those on 9; on the cervical shield there are two rows and on the anal plate they are all brought close together. The red parts are more or less thickly beset with short, fuzzy, dark hairs which are especially dense on the velvety patches and large tubercles mentioned. Venter from joint 8 to anus pale. Head yellowish-white with a deep brown transverse band around the mouth and the forehead, and an irregular spot of the same color on the top and on the front of each lobe. Thoracic legs dark brown; prolegs dusky.

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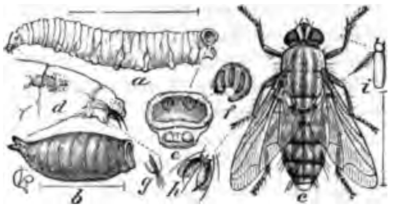
*Descriptions and Natural History of two Insects which brave the dangers of Sarracenia variolaris.—Trans. St. Louis Acad. of Science. By C. V. Riley, Ph. D.

The newly hatched larva is pale, with the dark bands noticeable principally on joints 4-7, the head uniformly pale-brown, and the tubercles scarcely noticeable and surmounted by one or more stiff hairs. In the second stage the tubercles become more prominent, but those on joints 4-7 are not relatively so much larger than the others. In the third stage the characters of the mature larva are assumed, except that the colors do not contrast so greatly, the short hairs are not so dense and the head is often unicolored.

Chrysalis—Uncharacteristic; varying from yellowish-brown to mahogany-brown in color; the head produced into a slight cone in front between the eyes, and the tip of the abdomen armed, in perfect specimens, with two straight converging thorns, and several smaller curled hooks.

Imago—Average expanse 0.8 inch*. Colors, glossy straw-yellow and black. Primaries with the basal half straw-yellow, varying from pale chrome to ochre; the terminal half brown-black with a gray and violet reflection; the two colors sharply separated across the wing at about a right angle from costa. Secondaries same as terminal half of primaries, but usually somewhat paler, especiplly toward base. Under surface uniformly purplish-gray, inclining to yellow basally, and with a somewhat darker median shade usually discernible on primaries. Head black,† with palpi beneath and antennæ yellow. Thorax of the same two colors, sharply separated across the shoulders. Legs yellowish, the tarsi with minute spines, the spurs often with a spinous tip. Abdomen yellowish at base, otherwise concolorous with secondaries.

The species is very variable, the dividing line of the two colors, on primaries, being usually across the middle, but in some specimens much nearer the base of the wing. A striking variety (two specimens) is of a uniform straw-yellow, with the faintest dusky shade across the middle and subterminal portions of primaries; while several have the dark parts more or less suffused with yellow.



SARCOPHAGA SARRACENIÆ - *a*. larva; *b*. pupa; *c*. fly, the hair lines showing average natural lengths; *d*. enlarged head and first joint of larva, showing curved hooks, lower lip *g*), and prothoracic spiracle; *e*, end of body of same, showing stigmata (*f*) and prolegs and vent; *h*. tarsal claws of fly with projecting pads; *i*, antenna of same. All enlarged

SARCOPHAGA SARRACENIÆ, Riley. Larva—0.30—0.85 inch long. Body composed of but 11 visible joints exclusive of the head; microscopically and transversely shagreened; transversely wrinkled, the hind wrinkle on each joint more particularly prominent laterally. Head extremely small, or ¼ as large as joint 1; showing a division into two maxillary lobes at the tip, and a larger labial lobe, beneath, with a small bunch of setous fibres issuing from it; the black retractile jaws, of the ordinary form, issuing between these lobes, and the antennae showing in two small rufous projections above the maxillary lobes; sparsely armed anteriorly with minute conical, sharp-pointed spines, decurved in front, directed backward beneath. Prothoracic spiracle pale rufous, retractile, sponge-like, studded with numerous lobules, divided at the end into a variable number of branches (6 being usually apparent, never more than 8), which in their turn ramify into lobules. Anal stigmatic cavity quite deep; the fleshy prominences on the carina surrounding it, sub-obsolete; the stigmata but slightly excavated below, the border brown, enclosing three brown openings, the lower ends of which reach to a circular clear space in the corneous and pale rufous peritreme. Anal prolegs quite small, with the longitudinal anal slit between, and a corneous plate in front of them.

Puparium—0.25-0.50 inch long; neither smooth nor highly polished, and varying from yellowish-brown to deep brown-black in color. Insections more or less distinctly traceable. Head and prothoracic joint retracted; the prothoracic spiracles, protruding and forming two small ears, about as long as joint 2; the mass of lobules hardened and rufous. Joints 2 and 3 constricted and flattened; 4 suddenly bulging. End of body squarely docked by spiracular cavity, the rim of which forms quite a ridge.

Imago—Length of body 0.23-0.56 inch. Head pale golden-yellow, especially when viewed from above, with a dark brown or bronze sheen, especially below; eyes ferruginous, in life; duller and bronze-colored in death; stripe between the eyes and all appendages jet-black, though showing, in fresh specimens, shades of brown or yellowish-brown, especially at inner base of antennæ and on maxipalps. Thorax pale ash-gray, with three prominent, dark, longitudinal dorsal vittæ, and two which are shorter, on each side; the two intervening pale dorsal spaces showing also a narrow darker line along their middle: wings slightly fuliginous; tegulæ sordid white; legs black, with the front thighs grayish beneath: cushions large and pale yellowish. Abdomen of the same gray—inclining, in some specimens, to pale golden-yellow, especially behind—checkered with black, the pattern varying with each change of light, but 3 longitudinal lines tolerably distinct from above, the side ones approaching or joining the medial one on the anterior part of each joint, and the whole looking checkered as the light falls on the sides: anus always, and frequently the hind margin of preceding or 4th abdominal joint, pale reddish-brown, the color deepening and becoming less noticeable in the dead specimen; the globular and highly polished male genital organ of a brighter and deeper reddish-brown.

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*The writer finds the extremes of his measurements 0.6 and 1 inch.

†The writer has observed some specimens with brown heads.

amount of nourishment obtainable by the larva — there is not much in coloration. The species agrees tolerably well with the description of CARNARIA except in having a red anus, and should perhaps be considered only a variety of this last.

The larva differs from Packard's description of that of CARNARIA in the character of the prothoracic spiracle, in lacking the 12 blunt spines around the anal spiracular region, and in having the clear space in the peritreme of the anal spiracles, by which it seems to agree more with his description of Calliphora.

I also find a fly frequenting the pitchers and living upon the remains at the base of the leaf that agrees with the description of *Sarcophaga carnaria* L., or the flesh-fly.

My attention has often been called to the fact that *Musca Cæsar*, L., the blue-bottle fly, is found in the leaves of the Side-saddle flower as well as in some other forms of pitcher plants. (See page 409, Packard's Guide.)

I have often seen specimens of *Musca domestica*, L., the housefly, near the pitchers, but have never seen them inside except when dead. Neither have I been able to raise them from any of the larvæ. It is said, however, that they are known to live in the insect remains.

In answer to the question, "How do these insects succeed in escaping from the pitchers and have apparently perfect freedom in them," Dr. Riley suggests that in the case of the flies it is probably due to the large foot-pads and elongated claws that perhaps reach through the pubescens of the leaf and fasten to the cellular tissue beyond. Their great strength seems also to aid them in escaping by means of a continued buzzing and gradual movement upward. The only fly that seems to escape readily is the Sarcophaga.

The moth has the tarsi covered with long spines which are usually tipped with "a corneous point." The larvæ are perfectly safe in their web-like scaffolding.

Some time was spent in studying all these insects to see if they had any part in aiding the plant in fertilization. None of the insects living in the tube seem to ever frequent the flower. They are either there to feed upon the tissue of the leaf itself or are attracted by the odor of the decomposing mass to feed upon it.

As living insects prey upon the leaf and macerating mass so birds often frequent these leaves to feed upon the living insects. One is often surprised to see the number of ragged holes in the sides of, especially, old leaves. Some of these holes are made by insects in which case shreds of the epidermis still remain.

In several leaves that I knew had been opened by birds I did not find a single living insect. They seem to especially enjoy the fat larvæ of the Sarcophaga fly. It is a well known fact that birds when they obtain a taste of a new food that is especially enjoyable to them seemingly cannot be satisfied till there is no longer a supply.. Perhaps this will explain the fact that in some localities the leaves will all be more or less torn while in others the leaves as a whole are without holes.

Though I have not been able to make any extended observation concerning the depredations of birds on the leaves, I have sufficient evidence to show that, in those years when the larvæ of the Sarcophoga fly are especially common, the birds prey to a great extent upon them.

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BOULDER CLAYS.

ON THE MICROSCOPIC STRUCTURE OF CERTAIN BOULDER CLAYS AND THE ORGANISMS CONTAINED IN THEM.

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BY DR. GEORGE M. DAWSON, D. S., F. G. S., F. R. S. CAN., ASSOCIATE R. S. M., AND ASSISTANT DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

(READ BEFORE THE CHICAGO ACADEMY OF SCIENCES JUNE 9, 1885, BY H. A. JOHNSON, M. D., F. R. M. S.)

In a paper read before the Academy in January, 1884, and printed in the bulletins of the Academy (vol. i, No. 4), H. A. Johnson, M. D., and B. W. Thomas, F. R. M. S., gave the results of an investigation by them of microscopic organisms in the boulder clay of Chicago and vicinity. This paper refers principally to certain remarkable bodies first found by these gentlemen in 1865–66–67, in specimens of the clay through which the lake tunnel, which supplies the city of Chicago with water from Lake Michigan, was being constructed. On the completion of the tunnel large numbers of the same bodies were observed in the filtrate from the city water supply, and which were subsequently proved to be identical with organisms described in 1871 by Sir J. W. Dawson from the Devonian shales of Kettle Point, Lake Huron. They have since been observed in the Devonian rocks of a number of widely separated localities, and are now believed by Sir J. W. Dawson to be macrospores of rhizocarps.* In accordance with this view the generic name of *Protosalvinia* is proposed by Dawson in the paper above referred to instead of *Sporangites*, which term is, however, still used in this paper. Properly speaking, this term would apply to the *Sporangia* containing these macrospores, and which are absent in the specimens in question. Mr. Thomas, in a note to the paper first quoted, refers to the additional discovery in boulder-clay from Minnesota, sent to him by Prof. N. H. Winchell, of several species of *Foraminifera*, evidently derived from the Cretaceous rocks of that region. Since this announcement Mr. Thomas has mounted for the microscope and examined many samples of boulder-clays from various places, and has favored me from time to time with a number of his preparations. He has also kindly prepared and mounted specimens of several boulder-clays and allied materials collected in Manitoba and the Saskatchewan region. At his request the notes made by me on these last and on a few of those first mentioned are here offered. This paper must, however, be understood to be merely of a preliminary and general character, being based on the examination of less than one hundred microscopic preparations. It may, it is hoped, be supplemented later by a more detailed report, including the discussion of a larger suite of specimens, from a greater number of localities.

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*Proc. A. A. A. S., 1883, and Can. "Record of Science," vol. i. See also paper by Mr. J. M. Clarke, American Journal of Science, vol. xxix, p. 284.

The microscopical investigation of these boulder-clays has resulted in the discovery of many objects which, while evidently of organic origin, are very difficult to name or classify, and require comparison with a wide range of bodies and reference to many works for that purpose. Mr. Thomas has also found that even in the case of those clays with which he is most familiar, each new lot of preparations mounted is almost sure to show forms not before observed, and that the field is an ever-widening one.

It is now, therefore, proposed merely to denote the classes of objects so far observed in the various boulder-clays, and when possible the genera to which the organisms belong, without attempting to catalogue them specifically. Neither is it here intended to enter into any further discussion as to the nature of the Macrospores occurring in some of the clays.

It should also be stated that most of the objects on the many slips examined, have been indicated by maltwood markings by Mr. Thomas, a circumstance greatly reducing the amount of labor involved in going over the material.*

BOULDER-CLAYS OF CHICAGO AND VICINITY.

The preparations examined representing the boulder-clay of Chicago and vicinity are as follows: From Chicago lake tunnel, 86 feet down, 5 slides; North Chicago boulder-clay, 60 feet down, 11; North Chicago clay, 64 feet down, 2; North Chicago, 65 feet down, 10; corner of Washington and Clark streets, eight feet down, 1; or 29 in all. These are so similar in their general characters and the class of objects which they present that they may be considered together.

The inorganic material in these clays, as represented by the above preparations, consists largely of quartz sand, in which few well-rounded grains appear, most being sub-angular and many quite angular and unworn. With these is a notable proportion of bottle-green particles of hornblende,

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*It should be explained that the material referred to in the succeeding notes is that part of the boulder-clay which is composed of particles of medium size, from which the very fine matter has, as a rule, been separated by decantation. This again has been sized by repeated decantations at intervals of one, two or three minutes. Mr. Thomas states that the greater number of examples of a given form are frequently thus obtained in material of a certain grade of fineness.

Among the most interesting bodies found in these clays are certain comblike objects which are regarded as Annelid jaws. Of these, four, all fragmentary, have been observed. They were at first supposed to be teeth from the lingual ribbon of some mollusk, but on more careful examination were found to be unlike the teeth of any mollusk of which figures can be found, and, moreover, to correspond almost exactly in form with some of the Annelid jaws described by Mr. G. J. Hinde from the Silurian and Devonian rocks of Canada.† One of the specimens shows a series of long and curved prongs. (Fig. 2.) Three others apparently belong to a single type, in which a nearly flat plate is armed along one edge with a series of small, close denticles arranged somewhat obliquely to the line of attachment. (Fig. 3.) Like the bodies last described they are of a pale straw color, differing in this respect from Mr. Hinde's specimens, which are said to be shining and black; but this difference may arise from the mode of preservation. They exhibit no reaction with polarized light, and are smooth and not distinctly granular. The ends of the prongs or denticles are worn and roughened as though by use.

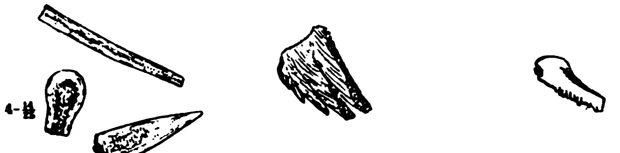
Fig. 1 (x130) Fig. 2 (x130) Fig 3 (x130)

Organisms from the Chicago boulder-clays.

Other bodies occurring in these preparations in smaller numbers need not be referred to in detail. Two broken specimens evidently represent Ostracoda. They show no well marked sculpture, but a minutely granular structure. The most perfect is .31 m. m. in length. A third specimen, somewhat larger, and also broken, is either a small Sphærium or a very young specimen of some larger shell. All three have adhering to them brownish shaly particles, which appear to indicate their origin, though it must be remarked that the shell substance is very well preserved and fresh-looking. Still another specimen is a broken piece of the edge of a large calcareous shell or carapace, beautifully marked, and possibly that of an ostracod of another species. The remaining objects observed are mere fragments, quite indeterminate in character. Among these are small pieces of a delicate ribbed shell, the ribs being square in cross-section; a rather large chitinous fragment, striated externally, but without any other apparent structure, and one or more pieces of straight tubular siliceous spicules probably belonging to some sponge.

The probable sources of the organic bodies in these clays is discussed subsequently in connection with those from other places.

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† Quarterly Journal of the Geological Society, 1879, p. 370.

BOULDER-CLAYS FROM BLOOMINGTON, ILL., 107 FEET DOWN.

This clay immediately underlies an interglacial deposit of soil and aty matter with remains of wood, etc.* Of this clay five preparations ly have been examined. The coarse material is here chiefly quartz sand, which by far the larger proportion is sub-angular. There are also a few ains of amethystine quartz, showing sharp conchoidal fracture. Several artz grains show inclusions, one of very small hexagonal red crystals, robably hematite. Hornblende grains are moderately abundant, but shaly agments, such as those which make up a large proportion of the material om the Chicago clays, are almost or altogether wanting. A few Macrospores actly like those previously noticed occur, together with one or two speci- ens of the pale brownish granular spines, or setæ, found in the Chicago ays. A small, flat, curved, finely-ribbed body in one of the slips resem- es part of the edge of a carapace. While therefore not altogether want- g in this clay, organic traces appear to be very scantily represented.

BOULDER-CLAYS FROM MEEKER COUNTY, MINN.

This material is derived from a well shaft sunk in Meeker County, at a pth of about twenty-two feet, and was transmitted to Mr. Thomas by of. N. H. Winchell, State geologist of Minnesota. Mr. Thomas has ade a large series of preparations from it, a number of which I have had e opportunity of inspecting.

As the Foraminifera contained in these preparations are being named d catalogued by Messrs. A. Woodward and B. W. Thomas, the remarks re given are confined principally to the general character and contents of e clay, with the object of comparing it with those from other localities.

The coarser material from this clay, as it appears in the preparations, is iefly quartz sand, which is generally sub-angular, though with some well- unded grains. Hornblende and mica appear in about the usual propor- ns, and two quartz grains with very beautiful inclusions were noticed, one ing probably either hornblende or rutile, the other possibly apatite. A rge proportion of the material, however, consists of rounded grains of ale, of gray or greenish-gray color by transmitted light, and not nearly so rk as the shale mixed with the Chicago clays. In specimens boiled in tric acid, the shaly fragments have become reddish from the oxidation of eir iron.

Of organic bodies present in these specimens of Minnesota clay, the *raminifera* are most prominent and important. They are evidently rived from the Cretaceous strata, and resemble those found in the western velopment of these rocks, both specifically and in mode of preservation. *otalidæ* and *Textularidæ* are most abundant, though specimens of *Glo- gerina* and other genera also occur. Next in abundance to the *Foramin-*

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*This stratum of soil is about 6 feet thick, and underlies 101 feet of boulder-clay. I do not know thickness of the clay deposit below the inter-glacial soil, but both the upper and lower clay deposits ry an abundance of glacial-marked boulders.—*B. W. T.*

ifera are remains of *Radiolaria*. Some difficulty was experienced in deciding the true nature of fragments of these bodies at first met with, but the subsequent discovery of numerous and often well-preserved specimens, and the observation by Mr. Thomas that they resist boiling in nitric acid, now leave no doubt as to their character. Several genera and quite a number of species are represented, and it will eventually be possible to determine many of these forms specifically. Most appear to belong to the Polysphæridæ and Cystidæ of Haeckel's classification. The constant occurrence of these bodies with the Cretaceous Foraminifera in the Minnesota preparations and in those from other places, with their absence from materials not equally characterized by the Foraminifera, leaves little room to doubt the common origin of both. Among miscellaneous objects from the Minnesota clay may be mentioned a few fragments apparently identical with the minutely granular spines or setæ described as occurring in the Chicago clays; also two broken portions of stout siliceous spicules, about .026 m. m. in diameter, one smooth, the other tuberculated; both tubular, and probably belonging to some sponge. Lastly, a single specimen of a very curious body, of straggling and irregular form, composed of numerous expansions differing in shape and size and pretty uniformly pitted and connected by narrow, smooth necks. As this is in one of the preparations which has been treated with acid, it must be siliceous. I can only suggest that it may be the siliceous cast of some foraminifer like *Aschemonella catenata* of Norman the arenaceous test of which has been composed of calcareous particles which have left pitted impressions on the cast. Against this is the fact of its small size, it being about .2 m. m. only in greatest diameter.

BOULDER-CLAY FROM CRETE, SALINE CO., NEB.

This material, Mr. Thomas informs me, was obtained from a single small excavation. It was forwarded to Mr. Thomas by Prof. G. D. Swezey, and is described by him in a letter to Mr. Thomas as a blue clay underlying the loess. The inorganic matter in the preparations made from it consists largely of fine angular and sub angular quartz grains, with a small proportion of green hornblende and much shale or earthy limestone in little particles which differ in color and texture. It is extremely rich in organic forms, chiefly Cretaceous Foraminifera, so much so that it seems probable that it is largely composed of the debris of the Niobrara division of that formation, and that a complete study of its contents would practically include that of all the forms occurring in the chalky limestone of that stage. The present notice of it must therefore be considered as of the most general and preliminary character only. Of this material a suite of thirty-one preparations has been examined, and in an enumeration of about one hundred of the best preserved forms, nearly fifty per cent belong to the *Textularidæ*, the remainder being made up in nearly equal proportions of *Globigerinidæ*, *Rotalidæ*, miscellaneous *Foraminifera* of other families, and *Radiolarians*, than common of coarse, thoroughly-rounded quartz grains. Hornblende and other crystalline minerals from the Laurentian or Huronian are also present, and there is a notable quantity of amethystine quartz in angular fragments. Comminuted gray shale, very finely ground, is moderately abundant. Bodies of organic origin are not frequent. In pretty carefully examining a series of six preparations, about ten only were met with. These are *Textulariæ* and rotaline *Foraminifera*, with one very small *Globigerina* and a couple of *Radiolarians*; one very perfect, oval and .09 m. m. longest diameter. (*Haliomma?*) A fragment was also found of bony substance, showing haversian canals and probably portion of a ganoid scale. There is also in these preparations a number of rounded and flattened grains, nearly transparent, though in some cases with a more opaque central spot, and surface minutely and regularly roughened. These were eventually determined by comparison to be fragments of some pearly shell, probably that of *Unio*, a form quite abundantly represented in the Cretaceous and Laramie rocks of the region. The appearance of an opaque nucleus in some examples appears to result from the non-penetration of the mounting medium to the centre of the larger grains.

BOULDER-CLAY FROM TEN MILES NORTH OF THE SOUTH SASKATCHEWAN, EAST OF MISSOURI COTEAU, TOWNSHIP 21, RANGE 10, WEST OF 3D PRINCIPAL MERIDIAN.

The material in six preparations from this clay differs from the last described only in the much greater quantity of comminuted shaly matter of a reddish-brown tint. Bodies of organic origin are here again scarce. No Foraminifera were found. Two or three broken pieces of minute rod-like pitted objects, very doubtfully referred to small spines of some *Echinoderm*, and evidently identical in character with that previously described from Saline County, Neb., were detected. Those occurring here are about .015 m. m. in diameter. Another somewhat similar object is rather stouter and with a roughened surface without regular markings. A small broken piece of some chitinous test was also observed, but on the whole this material is very barren.

BOULDER-CLAY FROM THE SOUTH SASKATCHEWAN, FIFTEEN MILES ABOVE THE ELBOW.

In the preparations from this clay—eighteen in number—the sandy material is much finer than in the two last. It is nearly half composed of shaly fragments of brown color, the quartz sand being also rather more angular than usual. It is richer in organic forms than either of the other specimens from the neighborhood of the South Saskatchewan. About half a dozen specimens of Foraminifera were recognized in the preparations, one being probably a small *Discorbina*, others *Textulariæ* and broken chambers of *Globigerinæ*. These are not so well preserved as in some of e other clays, and in some cases the shell itself appears to have been moved, leaving only a rough cast in calcite. ***Radiolarians*** are here (so r as the examination of a small quantity of material can be accepted as nclusive) even more abundant than *Foraminifera*, spherical, oval and rbinate forms all being represented, and in some cases in such connection th fragments of the abundant shaly material as to leave no doubt as to eir common origin with it. Small, partly rounded prisms from the shell *Inoceramus* are also present, together with a few pieces of straight hollow iceous spiculæ, one specimen of a minutely granular spine or seta, with a stinct medullary portion like some previously noticed, and .026 m. m. in ameter, and one of a portion of a body like that previously referred with ubt to an *Echinoderm* spine.

CONCLUSIONS.

In inquiring as to the derivation of the various organic bodies in the clays, is necessary to consider the situation of each locality with reference to own areas of the older rocks, from the disintegration of which they may have me. The Sporangites so abundant in the Chicago clays have been definly traced to the shales of the Devonian age, and have doubtless been ought to their present position from outcrops to the northward in the ichigan peninsula. It has already been stated that the bodies supposed to Annelid jaws may probably have been derived from the same beds, or m others of the Devonian or Silurian rocks of this part of the country. ith regard to the remaining bodies no definite statement can at present ventured, though there is every reason to believe that they might very ll have come from the same rocks.

In the clays from Bloomington, in the center of the State of Illinois, orangites are again the most characteristic bodies, though much less merous in correspondence with the greater distance from the shale outps. A few other objects associated with these are not dissimilar to those the Chicago clays.

Meeker County, from which the specimens of Minnesota boulder-clay re derived, is in the southern and central portion of the State, and is derlaid, according to Prof. N. H. Winchell by rocks of the Archæan riod, overlain probably, at least in some places, by shales of the etaceous. As might be anticipated from the absence of Devonian ks, both in this locality and the whole region to the north and northeast, orangites have not been observed in this clay. While the greater part at st of the organisms are evidently referable to the Cretaceous rocks, the ality lies to the northeast of the generally recognized edge of that forman. Prof. Winchell has, however, proved the existence of a number of liers of Cretaceous beyond the main area occupied by these rocks, and it probably from one of these, possibly not remote from the actual position the clay, that the Foraminiferæ and Radiolariæ have come.

The clay from Crete, Saline Co., Neb., is, as already observed, so rich in Cretaceous forms as to lead to the belief that it is largely composed of the debris of the chalky limestone of the Niobrara stage, and may rest upon or lie very near to the outcrop of these beds. I am not in a position to state whether the geology of the district bears out this conclusion. The map shows at least that Cretaceous rocks underlie this part of the State.

The material from Rosenfeld, Manitoba, shows a smaller number of forms, but these are equally characteristic of the Niobrara stage; the outcrop of which, though concealed by alluvial and other deposits, can not be many miles west of the position of the well, and also runs northward along the base of the Pembina escarpment, having been recognized at a point about fifty miles northwest of Rosenfeld on the Boyne River. ("Geology and Resources of the 49th Parallel," p. 78). As there is little probability of the existence of any Cretaceous rocks directly north or to the northeastward of this place, the occurrence of Cretaceous Foraminifera would tend to show that material derived from the northwest had been incorporated with the boulder-clay of this district.

The three localities near the South Saskatchewan may be treated of together, in so far as the origin of their organic constituents is concerned. The general movement of the material composing the glacial deposits of the northern plains in a southwesterly direction has already been demonstrated (see "Quarterly Journal of the Geological Society, 1875," p. 605; "Report of Progress of the Geological Survey of Canada, 1882–84," p. 139), and it would appear that the Cretaceous Foraminifera must also have been carried from the vicinity of the eastern Cretaceous outcrops at a great distance. It is true that the clays here rest on Cretaceous beds, but these are not as a rule calcareous, or such as to yield Foraminifera in the state of preservation of those found in these clays. The Niobrara limestones are not only unknown in the entire district from which the clays come, but their place appears to be taken in this region by the Belly river beds, which are arenaceous and argillaceous. Other organic fragments present in these clays may well have been derived from the Cretaceous or Laramie beds of the immediate neighborhood.

In reviewing the general bearings of the microscopical examination of these boulder-clays, representing as they do a few points only, scattered over a wide area in the central portion of the continent, it would be unwise to endeavor to draw any very definite or too general conclusions. The field appears to be a promising one for future inquiry, and the present paper can be regarded only as in the strictest sense, preliminary. It would appear, however, that of all the organic bodies met with none can be assigned with certainty to the glacial period or era of deposition of the boulder clay itself. The origin of most can be traced unequivocally to the older rocks, from which they have been derived, and incorporated with the boulder-clays. Of all the bodies enumerated the only ones which, on account of their presence in clays, holding otherwise different sets of forms, may possibly be of contemporaneous origin with them, are siliceous sponge (?) *spicules* and the peculiar spines or setæ several times referred to in the foregoing. To these may be possibly added the Ostracoda from the Chicago clay. While it is therefore probable that the examination of these organic fragments will serve to throw additional light on the direction of transport of material during the Glacial period—a point of particular value over the wide area of the plains, where the soft character of the rock precludes the test of direction of striation—it has so far failed to afford any certain information as to the actual conditions prevailing during that period. The negative evidence, reinforced by the fact that derived bodies have been perfectly preserved, so far as it goes, leads to a belief in the great scarcity of contemporary life. The occurrence of inter-glacial peats and the inclusion of wood and other vegetable matters in the boulder-clays of a number of widely separated localities in the West (see "Vegetable remains in Drift Deposits of the Northwest," by Prof. N. H. Winchell, Proc. A. A. S., 1875; "Report of Progress of the Geological Survey of Canada, 1882–84," p. 144) prove, however, that life was not constantly absent, and it may therefore reasonably be anticipated that further search will eventually lead to the definition in the clays of at least such contemporary organisms as may have been derived from these inter-glacial deposits, and possibly of others strictly contemporaneous with the boulder-clays themselves. The well-rounded character of a considerable proportion of the sand in some of the specimens points to prolonged water action, but there is no means of deciding to what extent in each case previously rounded sand grains have been included in the clays. The comparatively unworn appearance of the majority of the Foraminifera and other delicate objects, on the contrary, indicates rather tranquil conditions of deposit, and negatives the occurrence in the case of these materials of any extensive differential motion in the substance of the clay itself, which would infallibly have destroyed these very fragile organisms. Mr. Hugh Miller, in a carefully worked out paper on "Boulder Glaciation" ("Royal Physical Society, Edinburgh," vol. viii, p. 157), describes a fluxion structure in the Scottish till or boulder-clay, and notes instances of sand grains so shaped and striated as to represent microscopic glaciated boulders which he conceives to have been "slidden along and glaciated in these places in the clay." No confirmation of this observation is afforded by these clays. Though many grains of an elongated shape show what might at first be taken for such striation, it is apparent in almost every case on close examination that the lines are really structural and that the shape of the grains is here, as in ordinary sands, governed to a great extent by the pre existing cleavage or jointage planes of the material of which they are composed.

The microscopical examination of these boulder-clays bears out the conclusion arrived at from their macroscopic characters that, while largely composed of far-traveled material, they invariably contain a considerable proportion of material of local, or proximately local, origin.

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BULLETIN

OF THE

Chicago Academy of Sciences.

SOME POINTS

ON THE

MICRO-CHEMISTRY OF FATS.

By JOHN H. LONG, Sc. D.

CHICAGO:
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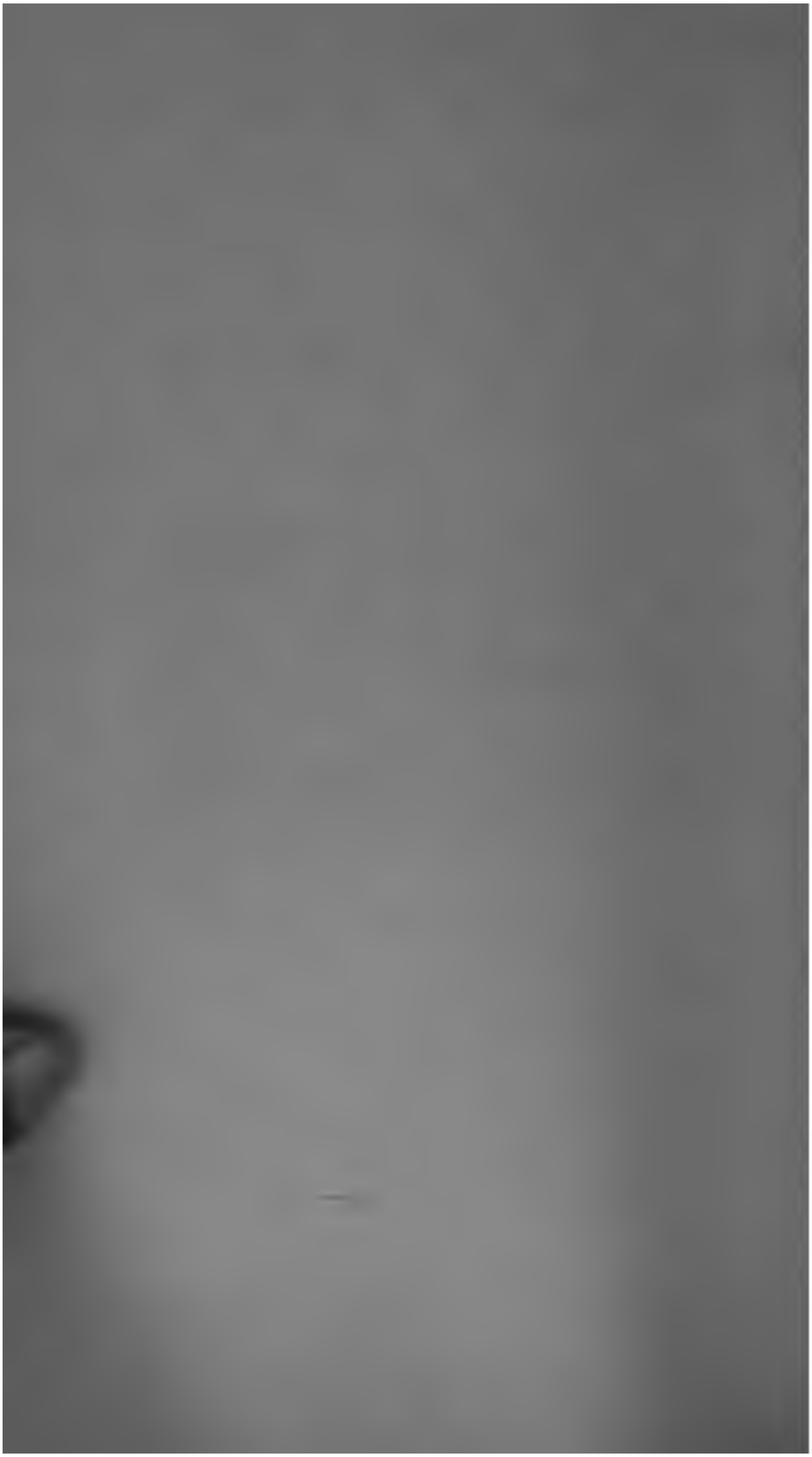

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CHICAGO ACADEMY OF SCIENCES.

SOME POINTS ON THE MICRO-CHEMISTRY OF FATS.

BY JOHN H. LONG, Sc. D.

Before the beginning of this century investigations concerning fats nd oils were confined almost entirely to the preparation of a few soaps, lasters and burning fluids. The action of alkalies on fats was explained y assuming that the two classes of bodies united without excluding any hing. Even the fact that a metallic compound, as lead acetate, could recipitate an alkaline soap, seemed to suggest little. Scheele, in 1779, eparated glycerine from olive oil, and later, from other fats; but, like riestley, wedded to the old Phlogiston theory, he failed to perceive the reat importance of his discovery.

The first satisfactory explanation of the nature of fatty bodies was urnished by the work of Chevreul, commenced in 1811, and by the nalyses of others, who, taking up the investigations suggested by this hemist, soon showed the general correctness of his views. Fats were hus proven to be ethers of organic acids, in which glycerine was usually he basic part, and saponification, accordingly, consisted in replacing this lycerine by a metallic oxide. The investigations of Wurtz on the composition of glycerine, and of Berthelot and Heintz on the synthesis of ats, bring this part of the subject down to the present time.

The constitution of these bodies being settled, it now remained to tudy their various reactions, and improve methods of separation and dentification.

We may regard the following formulas as established:

		Molecular weight.
Glycerine	$(C_3 H_5) O_3 H_3$	92
Stearic Acid	$(C_{18} H_{35} O_2) H$	284
Palmitic Acid	$(C_{16} H_{31} O_2) H$	256
Oleic Acid	$(C_{18} H_{33} O_2) H$	282
Butyric Acid	$(C_4 H_7 O_2) H$	88
Caproic Acid	$(C_6 H_{11} O_2) H$	116
Tri-stearin	$C_3 H_5 (C_{18} H_{35} O_2)_3$	890
Tri-palmitin	$C_3 H_5 (C_{16} H_{31} O_2)_3$	806
Tri-olein	$C_3 H_5 (C_{18} H_{33} O_2)_3$	884
Tri-butyrin	$C_3 H_5 (C_4 H_7 O_2)_3$	302
Tri-caproin	$C_3 H_5 (C_6 H_{11} O_2)_3$	386

With very few exceptions, all natural fats consist of mixtures of the last five bodies, and numerous processes have been suggested for separating the constituent parts.

A rough separation can be effected by partial crystallization from some menstruum, or by melting and cooling gradually, in which case the more solid fats separate first.

Fats containing volatile acids can be treated in this way: They are first decomposed by saponification, and treated with dilute sulphuric acid to throw out the free fatty acids. The volatile ones, as butyric, can now be distilled off, or washed out by hot water, in which they are soluble. Methods of analyzing butter are based on these principles. The separation of stearic, palmitic and oleic acids from each other is a problem of very great difficulty, and can be best accomplished in this way, as given by Oudemans (*Fres. Zeit. 1867, p. 454.*) After saponification and precipitation of the fatty acids, an alcoholic solution of the latter is prepared, from which lead acetate throws down the lead salts. These are dried and treated with ether, in which oleate of lead is soluble, while the stearate and palmitate are not. The acids can be separated from the lead readily and weighed, or further treated. The method is not very accurate, as the lead oleate is not easily soluble in cold ether, while, if the latter is warmed, small amounts of the other salts pass into solution.

Palmitic and stearic acids are separated from each other by the process of Heintz. The mixture is dissolved in hot alcohol, and treated with a hot alcoholic solution of magnesium acetate, in such proportion that only about one-seventh of the amount necessary for total precipitation is added. Under these circumstances nearly pure magnesium stearate separates.

From the residue a second and third precipitates are made, and so on. The final ones consist chiefly of magnesium palmitate.

By decomposing all the fractions and repeating the process, it is possible to obtain the one acid in several portions practically free from the other. By uniting and weighing the fractions the desired result is obtained. This process was proposed by Heintz in 1851 (*J. B., 1851, p. 639*), and modified by himself and others later.

As an analytical method it is seldom followed, but for obtaining the ure acids for experimental purposes it answers very well, and was mployed by Heintz in preparing the materials for his work on the syn-hesis of fatty bodies.

The determination of the amount of stearic and palmitic acids in a nixture is usually accomplished by this indirect method.

The molecular weight of stearic acid being 284, and that of palmitic eing 256, one C.c. of a $\frac{1}{10}$ normal sodium hydrate solution would neu-ralize 28.4 Mg. of the former and 25.6 Mg. of the latter. By a simple alculation from the weight of the mixed acids taken, and the C.c. of lkali used, the proportions of the two acids may be deduced. The nethod is fairly accurate when due precautions are taken. The acids nust be dissolved in pure alcohol, or alcohol of known acidity, and a roper indicator, as phenol-phtalein, must be used.

Account must also be taken of the fact that the free acids hold some ater, about 3.25 per cent. These equations may be employed in calcu-ating the amounts of acid in such a mixture:

Let x = wt. of stearic acid.
y = wt. of palmitic acid.
a = wt. of mixture.
b = wt. of $NaOH$ used.

$$\text{Then} \quad x + y = a$$
$$\frac{40}{284} x + \frac{40}{256} y = b$$
$$\text{From which} \quad x = 10.143\,a - 64.914\,b$$

A determination of the fusing point of a mixture of the two acids may ive some idea of the amounts of each present, but the uncertainties of he method are sufficiently indicated by this table:

Mixture of Stearic.	Palmitic.	Melts.	Solidifies.	Texture.
100	0	69.2	69.2	Crystalline scales.
80	20	65.3	60.3	Fine needles.
60	40	60.3	56.5	Non-crystalline.
40	60	56.3	54.3	Large plates.
30	70	55.1	54.0	Non-crystalline.
20	80	57.5	53.8	Indistinct needles.
0	100	62.0	62.0	Scales.

To be of value these tests must be made with very great accuracy, and oth melting and solidifying points must be found.

In practice, the processes mentioned prove of little value in the identi-cation of a majority of the natural fats. In some cases so-called color ests are of use here. These depend on the tints produced by certain eagents when mixed with different fatty bodies, and among the reagents ay be mentioned sulphuric acid, nitric acid, zinc chloride, sodium ydrate, hydro-chloric acid and sugar, and several others. At first sight, one may be pleased by the simplicity of these tests, but on trying a large number uncertainty creeps in, when it is found that various mixtures may be made to yield the colors supposed to be characteristic of some one substance.

It has been known for a long time that nearly all fatty bodies will crystallize under appropriate conditions, and in forms which are, to a certain degree, characteristic.

The study of a few of these fatty crystals is the main object of this sketch. The literature of the subject is meager and very unsatisfactory. Several authors since Chevreul, Berthelot and Heintz, have referred in a general way to the crystalline forms assumed by natural and artificial fats when crystallizing from various solvents, but evidently, no very great importance was attached to these observations. Attempts were made to distinguish between butter and some of its substitutes by microscopic tests, it being claimed that pure butter was characterized by an absence of small crystals, while other fats, used to adulterate it, possess a multitude of these, especially visible when viewed by polarized light. Some ten years ago, Hassall, in his work on food adulterations, showed the fallacy of this, which fact, however, seems to have been lost sight of by later observers. In a French scientific paper I found, some years ago, reference to the crystallization of certain animal fats, with the statement that from this could be developed a means of identification. Unfortunately, I have lost my memoranda relating to this paper, and can not now recall where I saw it. I think it was published between ten and fifteen years ago, and it was among the first notices relating directly to identification.

In the last five years the subject has received more attention. The following pages embrace the results of my own experiments, commenced in the winter of '82–'83, and which are still in progress. In my investigations I have tried several methods of preparation for microscopic examination.

First Method. Small portions of the fats in question were pressed down to a thin layer between a cover glass and slide, and then examined by ordinary and polarized light, using powers from 75 to 250 diameters. In this way crystals already existing can be detected, but in most cases there is little characteristic about them. Below, under the discussion of butter, it will be seen what use can be made of them.

Second Method. Here a small fragment of the solid fat was melted on a slide, and allowed to cool slowly. In this manner crystals can be obtained, but solidification is usually too rapid to permit large and characteristic forms to appear. By softening the fat by addition of a little olive oil, somewhat more satisfactory results can be obtained, but in neither case is a free and perfect crystallization possible, as in the following methods.

Third Method. This is the ordinary procedure of crystallization from solution. A small amount of fat was dissolved in ether, carbon bisulphide, chloroform or other menstruum in a beaker or watch-glass, and allowed to stand, until by spontaneous evaporation most of the liquid had passed off. After removing the mother liquor, the deposited crystals were examined on slides in the usual way.

In this way very perfect crystals can be made, but they are not as sharp as when made as follows.

Fourth Method. Here the fats were dissolved as before, and a drop or two transferred to a slide. In a short time, by spontaneous evaporation, a film makes its appearance on the surface of the drop, and at this stage a cover is carefully placed over it, and the slide is allowed to stand until complete crystallization takes place. This requires, in some cases, but an hour, while in others a day or more is necessary. Of all solvents I have found chloroform the most serviceable, and nearly all the crystals described below were made by its use.

I pass now to a discussion of the several fats.

BUTTER.

I have above referred to the opinion once held, that pure butter is composed of non-crystallized fats, and when viewed by polarized light exhibits no refraction phenomena. Hassall and others, as mentioned, have pointed out that on standing, butter soon loses this peculiarity. It has also been found that perfectly fresh butter, and even cream, may sometimes show crystalline forms.

I have been able to confirm these observations as regards butter, but have never found crystals in cream.

When butter is freed from water and salt by melting at a low temperature, and then dissolved in chloroform and crystallized by the fourth method. several forms are observed, the most usual of which are given in Figs. I, and II.*

Crystals like Fig. I, having a diameter of $\frac{1}{250}$ to $\frac{1}{100}$ inch, are very abundant. They consist of fine silky filaments radiating from a center, the field presenting a somewhat wavy appearance, well shown in the figure. Viewed by polarized light the bright crystal on a dark ground appears marked by a cross, as shown under tallow. Fig. II shows another interesting form. We have here a portion resembling Fig. I joined to, or extending into a plate-like bundle of needles similar to some mentioned below.

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* The cuts were made from micro-photographs by the photo-engraving process, with two exceptions. The bees-wax plate and that by polarized light were made from drawings.

In some cases these needles lie so close together as to be undistinguishable from plates, with ordinary powers, and are similar to the common plates of lard or mutton tallow.

Fig. III bears a striking resemblance to Fig. I. The crystals represented here were obtained from pure stearin, by crystallizing it at a very low temperature. On allowing a drop of the chloroform solution, on a slide, to remain over night, the field was found, when examined in the morning, to be thickly covered with the forms here shown.

Nothing else could be seen, and these disappeared on the application of a slight degree of warmth. So delicate are they that I made several attempts to photograph them before succeeding, and then only after removing my instruments to a cold room. It is possible the butter crystals may have a similar composition. Other forms observed will be referred to below.

BUTTERINE.

Samples of butterine, as now found in the market, show a large number of forms when crystallized from chloroform solution. I have observed forms very closely resembling Figs. IV, VII, XV and XVI. We have here a complex body, and the proportions of the several fats used are, without doubt, of great influence on the manner of crystallization. I wish to reserve the subject of butterine crystals for a fuller discussion at a future time, and hence, will not enter into details here.

MUTTON TALLOW.

Mutton tallow and others to follow consist almost entirely of the glycerides of palmitic, stearic and oleic acids, that is of acids of large molecular weight, which are not readily volatile without decomposition. Butter fat differs from these substances in this, that it contains 8 to 10 per cent. of glycerides of volatile acids. There is necessarily a marked physical difference between butter and other fats, and we should expect corresponding differences to appear in the microscopic forms. Figs. IV, V, VI, VII, VIII and IX give the chief forms found in mutton fat. All of these crystals can be found on one slide, and frequently two or three in the same field. It is not easy to say which is the most characteristic or numerous. Nos. IV, V and VI are readily produced, and are, in a certain sense, primary forms. They are among the first which become clearly defined on the evaporation of the chloroform, and are very stable, remaining many months, perhaps years, in perfect shape. Nos. VII, VIII and IX are peculiar. Crystals separate from chloroform solutions of mutton fat very quickly, some forming within a few minutes, while others separate out after a longer time. Very soon a field is found which consists of well defined rhomboidal plates, Fig. VII, which differ from Fig. IV in this, that they are shorter, and, as will be seen, less stable. If one watches them carefully, he will find them undergoing a change by splitting in the direction of their greatest lengths into bundles of needles. Soon these diverge from each other at the ends, giving the appearances well shown in Figs. VIII and IX. The divergence is often greater than here shown.

I have followed these changes very closely with the microscope, and in one instance made photographs of two fields to show this.

Fig. VIII is, in fact, an enlarged portion of the crystals of Fig. VII, and was taken four hours later. This change of rhomboidal plates like Fig. VII, to bunches of divergent needles, as shown in VIII and IX, is somewhat characteristic of mutton tallow. Growth and change of crystals can be observed in nearly all fats, but this peculiar change I have not noticed elsewhere.

BEEF TALLOW.

Very fine crystals can be obtained from this substance, but the variety is probably not as great as in the case of mutton fat. The more usual forms are represented in Figs. X, XI, XII and XIII. Very frequently I have observed crystals which differ from X only in this, that the needles terminate without crossing at the center. Figs. XI, XII and XIII are well represented. The last named is one of the commoner forms found in the fat of the dog. In Fig. XI the nucleus is not quite in the center; but I have found in tallow many crystals in which it is in the center, and when such are viewed by polarized light we obtain the effect well given in Fig. XIV, the cross being exactly similar to that referred to under butter. I have occasionally found in pure tallow masses of crystals similar to those of Fig. IV. These are more frequently found when the tallow is mixed with a small amount of fatty oil.

LARD.

Lard differs, qualitatively, very little from beef or mutton tallow, but quantitatively, it is characterized by a larger amount of olein. The microscopic forms are not numerous. Figs. XV and XVI show those most commonly seen. The rhomboidal plates of XV are usually sharply defined and transparent, as they are very thin. They resemble closely the plates found in mutton tallow. In Fig. XVI we have a combination of an imperfect plate with a plumose tuft, somewhat similar to a form found in butter, but not quite the same. Another form seems to consist of very small plates which have undergone a partial change by sending out spines as in some of the mutton tallow crystals. The spines are, however, very short and sharp. It is possible that Fig. XVI grew in a somewhat similar manner. A change, in some degree analogous to this, may be observed by crystallizing beeswax from chloroform. The plates which first form are equilateral rhomboids, but after a time these change in a very remarkable manner. The points farthest apart become blunt, and send out litt spicules. These grow by curving outward until the dumb-bell of Fi XVII is reached. The first and intermediate forms are also shown i XVII, and the process of change can be readily followed by the micr scope.

In mixtures of lard and tallow numerous plates resembling XV can b found, and, in general, everything found in each, provided proper propo tions be taken. When equal parts of the two fats are mixed the crysta formed are frequently of the types shown in Figs. XVIII and XIX. Fi XVIII is very characteristic, consisting of plates expanded at one end int tufts of curved needles. In Fig. XIX we have a number of over-lyin plates, the ends of which have grown into tufts. By varying the propo tions, very different results can be obtained. When the tallow is large in excess a very common form is produced, shown in Fig. XX. Thi form polarizes as XIV. Needles form much more readily than plates.

HUMAN FAT.

In examining the fats above mentioned I took for solution portion representing the average composition of the whole substance. Melte human fat readily separates on cooling, into two layers, a liquid, and semi-solid mass. For my tests I worked with the latter, which had th consistency of lard.

Two forms are readily found on microscopic examination, and beyon these not much more. These are well shown in Figs. XXI and XXII, which those like XXI predominate. Sometimes the very fine needl radiate from the center in all directions, and without curvature.

DOG FAT.

The fat of the dog crystallizes from chloroform solution in fine wav needles, radiating from a center. Fig. XXIII shows a very commo appearance. Other forms are similar to fine crystals of butter shown i Fig. I, and to the tallow-lard mixture of Fig. XX. The cross by polarize light is perfectly exhibited.

CAT FAT.

Fig. XXIV shows a form of crystal readily obtained from solutions cat fat. Other forms consist of imperfectly shaped plates observed i mutton and butter.

It will be observed that butter fat and the last three described hav this in common. Their ordinary mode of crystallization is in exceedingl fine lines or needles radiating from a nucleus. The lines of lard, bee tallow, or mutton tallow, are not as fine or feathery as those just mer tioned. Butter and the other fats resemble each other, even when ver fresh, in having a strong and characteristic odor, showing the presence of relatively large amounts of volatile substances. These volatile matters are doubtless glycerides of lighter acids, and the addition of a small amount of such substance makes a change in the appearance of the crystals, as I have found by adding a little artificially prepared glycerine butyrate to some mutton tallow.

OTHER FATS.

In his classic study of the composition of fats Berthelot prepared a number of them artificially, by heating mixtures of glycerine and the fatty acids. (*J. B., 1853, p. 451.*)

By heating equal weights of glycerine and stearic acid in a sealed glass tube to a temperature of 200°C. for 26 hours, he obtained, after eliminating the uncombined acid and glycerine, mono-stearin. In like manner he prepared di-stearin and tri-stearin, and the glycerides of other acids.

Soon after this Heintz went through the same processes, obtaining like results. (*J. B., 1854, p. 447*). According to the process proposed by Berthelot, I have prepared several of the fats, and studied their crystalline forms. The results have not been altogether satisfactory, or just what I anticipated. There are many difficulties in the way of purifying some of the products when prepared, but until this is done I think we cannot expect to reach a fair explanation of the many forms observed in these crystallizing bodies.

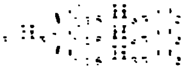
Several hypotheses may be presented to account for the numerous modes of crystalline aggregation observed in the photographs I have made, but it must be admitted that no one of them amounts to a satisfactory explanation. It is usually held that the ordinary phenomena of di- and tri-morphism, observed among mineral crystals, are brought about by variations of temperature at time of crystallization. It is also known that several simple substances of perfectly definite composition crystallize in different forms from different solvents.

Among the simpler fatty bodies I have noticed a remarkable variety of forms in samples of pure stearic acid, prepared by fractional precipitation, and in pure stearin.

If we assume that these samples were not absolutely pure, which is of course probable, there comes up another hypothesis worthy of consideration. Williamson, in advancing his theory of etherification (*Chem. Soc. Quar. Jour., IV, 229*), and Clausius in discussing certain phenomena of electrolysis (*Pogg., CI, 338*), proposed an explanation of the nature of solutions, which has been of great assistance in the study of many reactions. They held that the component parts of a molecule in solution can not be considered as firmly linked to each other, but as continually moving about, exchanging places with corresponding parts of other molecules.

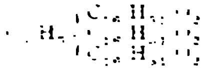
KCl and $NaNO_3$ in solution form some $NaCl$ and KNO_3, so tha at any one time we may consider four substances present, instead of two This hypothesis may be extended to molecules of greater complexity.

Referring to the formulas on page 174, we see that we have in mos natural fats three groups:



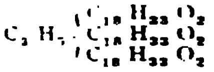
$$C_3H_5\left\{\begin{array}{l}C_{18}H_{35}O_2\\C_{18}H_{35}O_2\\C_{18}H_{35}O_2\end{array}\right.$$

Tristearin.



$$C_3H_5\left\{\begin{array}{l}C_{16}H_{31}O_2\\C_{16}H_{31}O_2\\C_{16}H_{31}O_2\end{array}\right.$$

Tripalmitin.

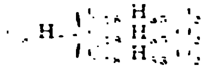


$$C_3H_5\left\{\begin{array}{l}C_{18}H_{33}O_2\\C_{18}H_{33}O_2\\C_{18}H_{33}O_2\end{array}\right.$$

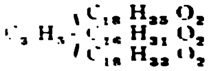
Tri-olein.

In solutions, more could be formed from these, as:

$$C_3H_5\left\{\begin{array}{l}C_{18}H_{35}O_2\\C_{16}H_{31}O_2\\C_{16}H_{31}O_2\end{array}\right.$$



$$C_3H_5\left\{\begin{array}{l}C_{18}H_{35}O_2\\C_{18}H_{35}O_2\\C_{18}H_{33}O_2\end{array}\right.$$



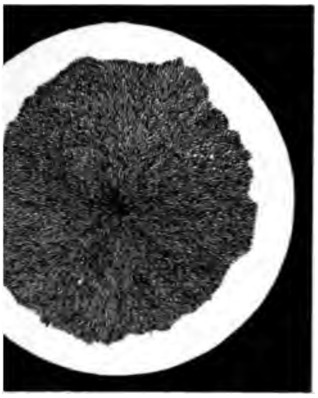
$$C_3H_5\left\{\begin{array}{l}C_{18}H_{33}O_2\\C_{16}H_{31}O_2\\C_{18}H_{33}O_2\end{array}\right.$$

If we consider a fourth or a fifth fat present, as in the case of butter, a much greater number of combinations would be possible, and I think it probable that at the time of crystallization some of these secondary forms would separate out, just what ones, depending, of course, on conditions of temperature and concentration. At one instant the conditions may be right for the formation of one nucleus, and at the next for the formation of another.

While many combinations are possible, a few are more probable because of their stability, just as in the cases of isomers among alcohols and hydrocarbons.

I believe that by working at lower temperatures, I could have obtained an even greater variety of crystalline aggregates than indicated above, as was indeed suggested by my experience with stearin. These considerations lead me to think that the microscopic identification of mixtures of fats is a problem of much greater difficulty than might appear at first sight. I think ultimately a great deal may be accomplished in this direction, but until the various effects of temperature and percentage composition are understood and until they have been demonstrated by actual experiment, I think it unwise to lay very great stress on results obtained in this way.

[illegible] January, [illegible]



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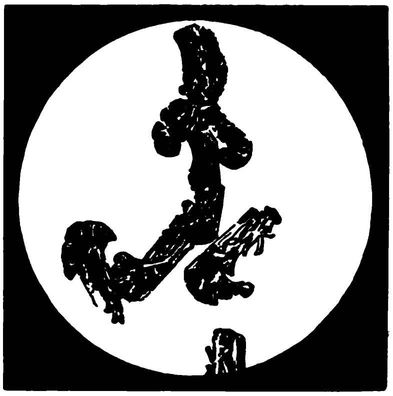

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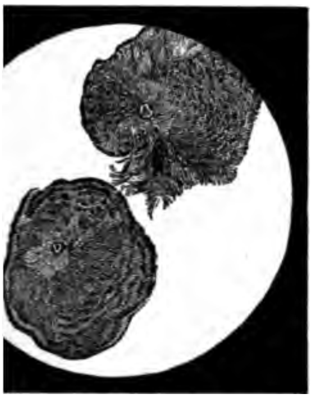

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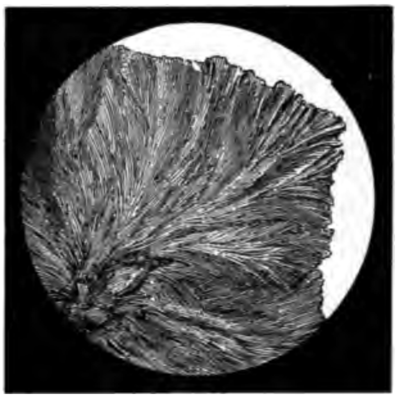

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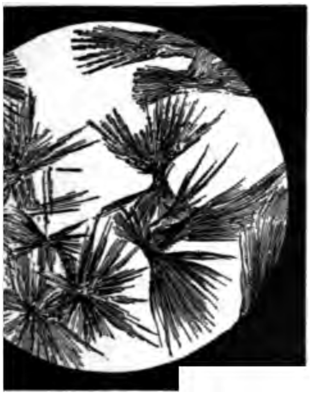

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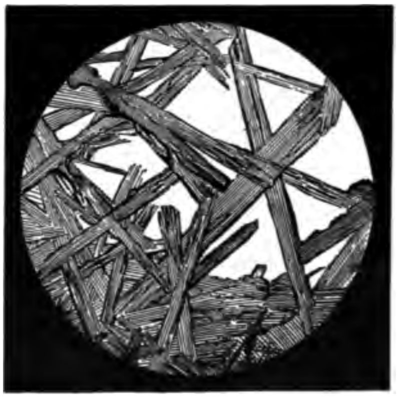

VI.

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VIII.

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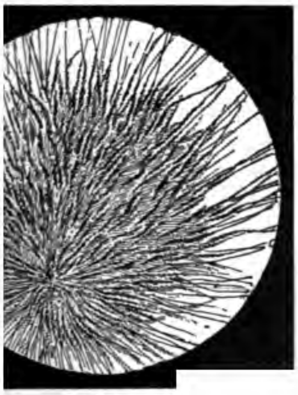

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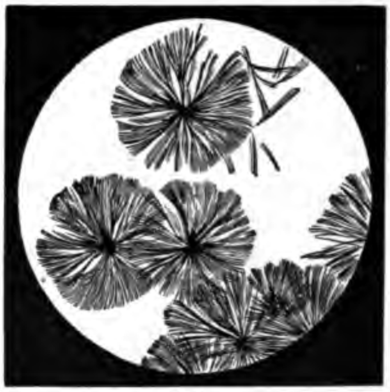

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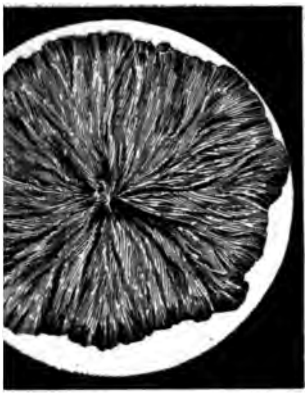

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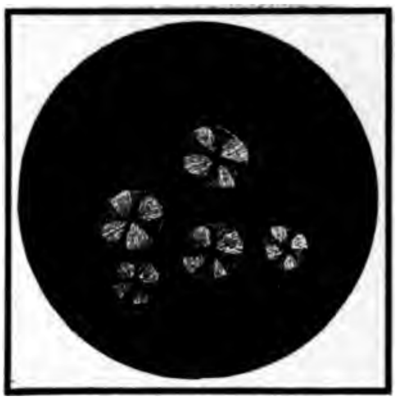

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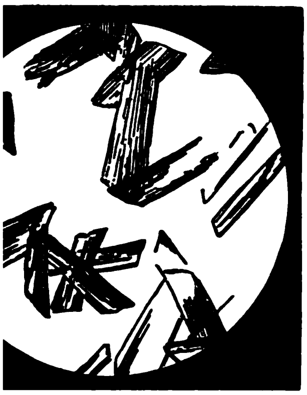

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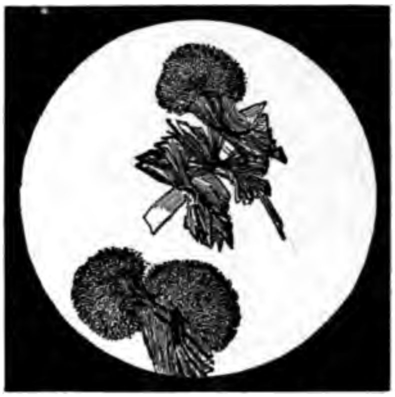

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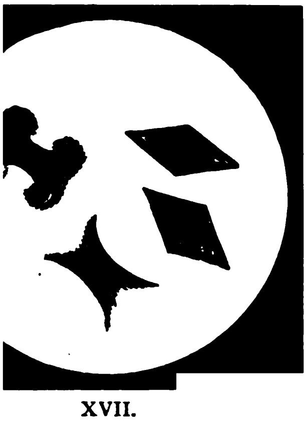

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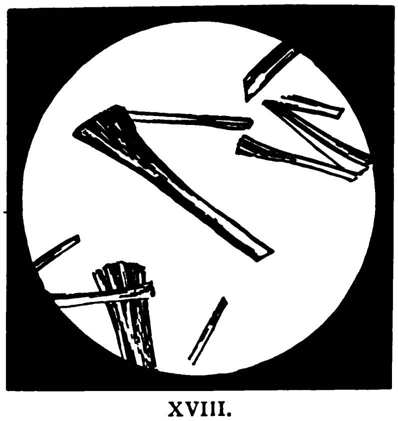

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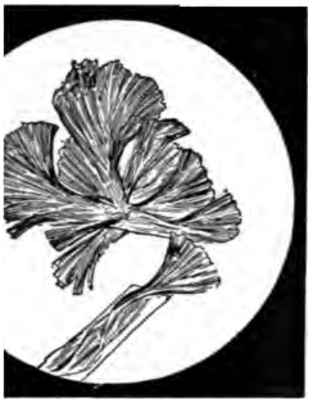

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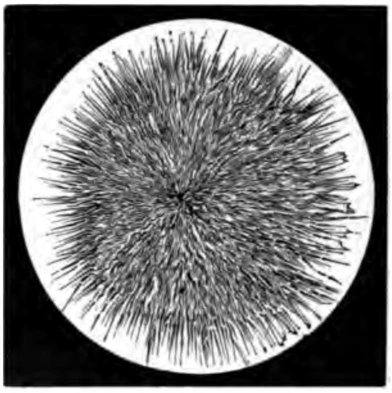

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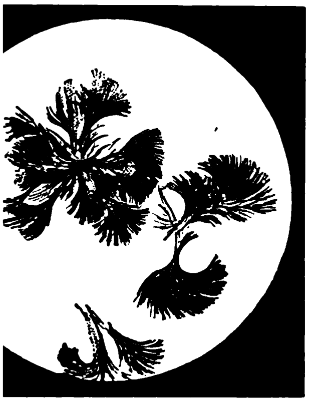

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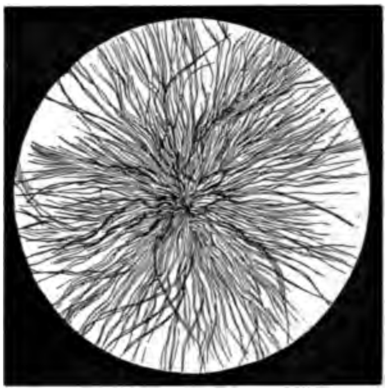

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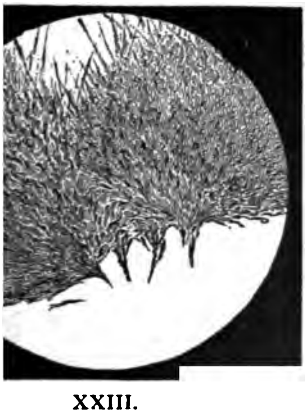

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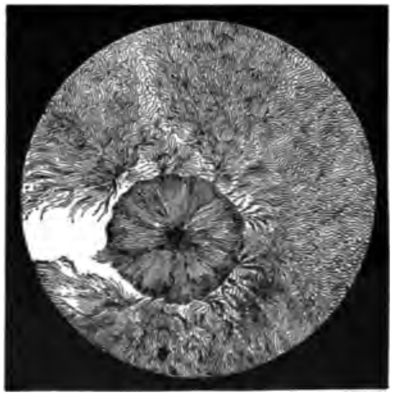

XXIV.

Vol. 1. *No. IX.*

BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCE.

ON RHIZOCARPS

IN THE

ERIAN (DEVONIAN) PERIOD IN AMERICA.

833943
APR 29 [illegible]

BY SIR WILLIAM DAWSON, LL.D., F.R.S.

CHICAGO:
[illegible] & SONS, PRINTERS.
1886.

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" The oldest bed of spore-cases known to me is that at Kettle Point, Lake Huron. It is a bed of brown bituminous shale, burning with much flame, and under a lens is seen to be studded with flattened disc-like bodies, scarcely more than a hundredth of an inch in diameter, which under the microscope are found to be spore-cases (or macrospores) slightly papillate externally, (or more properly marked with dark pores,) and sometimes showing a point of attachment on one side and a slit more or less elongated and gaping on the other. When slices of the rock are made, its substance is seen to be filled with these bodies, which, viewed as transparent objects, appear yellow like amber, and show little structure, except that the walls can be distinguished from the internal cavity, which may sometimes be seen to enclose patches of granular matter. In the shale containing them, are also vast numbers of rounded, translucent granules, which may be escaped spores (microspores)."

The bed containing these spores at Kettle Point was stated in the reports of the Geological Survey of Canada, to be 12 to 14 feet in thickness, and besides these specimens it contained fossil plants referable to the species *Calamites inornatus* and *Lepidodendron primaevum*, and I not unnaturally supposed that the Sporangites might be the fruit of the latter plant. I also noticed their resemblance to the spore-cases of *L. corrugatum* of the lower Carboniferous, (a Lepidodendron allied to *L. primaevum*,) and to those from Brazil described by Carruthers under the name *Flemingites*, as well as to those described by Huxley from certain English coals, and to those of the Tasmanite or white coal of Australia. The bed at Kettle Point is shown to be marine by its holding *Spirophyton*, and shells of *Lingula*.

The subject did not again come under my notice till 1882, when Prof. Orton of Columbus, Ohio, sent me some specimens from the Erian shales of that state which on comparison seemed undistinguishable from *Sporangites Huronensis*. These shales have been described as to their Chemical and Geological relations, by Dr. T. Sterry Hunt, Am. Journal of Science, 1863, and by Dr. Newberry, in the Reports of the Geological Survey of Ohio, vol. I, 1863, and vol. III, 1878.

Prof. Orton read an interesting paper on these bodies, at the meeting of the American Association in Montreal, in which were some new and striking facts. One of these was the occurrence of such bodies throughout the black shales of Ohio, extending "from the Huron River on the shore of Lake Erie to the mouth of the Scioto in the Ohio valley, with an extent varying from ten to twenty miles in breadth," and estimated to be 350 feet in thickness.* Another was the absence of any traces of

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*In a letter, received since the reading of this paper, Prof. Orton states that " borings in the Ohio black shale have penetrated it to a depth of 1800 feet without reaching the bottom." So that its whole thickness is probably much greater than stated in the text. Specimens of these borings kindly sent to me by Prof. Orton, are well filled with sporangites throughout the thickness of the shale as far as penetrated. —B. W. T.

Lepidodendroid cones, and the occurrence of filamentous vegetable natter, to which the Sporangites seemed to be in some cases attached in groups. Prof. Orton also noticed the absence of the trigonal form, which belongs to the spores of many Lepidodendra, though this is not a constant character.* In the discussion on Prof. Orton's paper, I admitted that the facts detailed by him shook my previous belief of the lycopodiaceous character of these bodies, and induced me to suspect, with Prof. Orton, that they might have belonged to some group of aquatic plants lower than the Lycopods.

In the same discussion, Prof. Williams, of Cornell University, mentioned that he had found similar bodies in the Hamilton shales of New York, and that they were associated with the curious pinnately leaved plant *Ptilophyton vanuxemii*, an observation to which I subsequently referred in discussing the affinities of this fossil, in a report on the Erian plants of Canada, published in 1882.† Prof. Williams was kind enough to send me specimens, in which, however, the round spore-case-like bodies were much less distinct than in the specimens from Ohio and Lake Huron. In the report above referred to I have also noticed the occurrence of rounded spore-like bodies in association with the stems of *Trochophyllum* of Lesquereux from the lower carboniferous of Pennsylvania, and of which specimens were submitted to me by Mr. Lacoe, of Pittston, and Prof. Lesquereux. *Trochophyllum* I regard as closely allied to or perhaps congeneric with *Ptilophyton*, and in the report already referred to I have argued that these plants were probably aquatic.

Still more recently Prof. J. M. Clarke, of Northampton, Mass., was so kind as to send me two fragments of rock containing *Sporangites* similar o those above mentioned—one from the Genessee shale of Canandaigua, N. Y., and another from the Corniferous Limestone. In the latter these bodies retain their globular form, though some are partially crushed in uch a way as to show their membranous character. In slices prepared by Prof. Clarke the wall is seen to be thin and carbonaceous, with indica-ions of a dense cellular structure, and some of the specimens show a pro-ecting aperture or point of attachment at one side, giving them a somewhat pear-shaped appearance. The size of all these macrospores from he Erian of New York is nearly the same with that of Lake Huron pecimens. Those found with *Trochophyllum* in the Lower Carboniferous re much larger.‡

No certain clue seemed to be afforded by all these observations as to the precise affinities of these widely distributed bodies; but this was fur-ished shortly after from an unexpected quarter. In March, 1883, Mr.

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*On the source of the Bituminous matter of the black shales of Ohio. Proc. Am. Asso. 1882.

†Report on Erian Plants of Canada, Part II.

‡Prof. Clarke has described his specimens in the American Journal of Science, April, 1885, and has ticed some interesting points to be referred to in the sequel.

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me the generic name *Protosalvinia*, in case the affinities which I think dicated by their structure should be fully established in the future. In e meantime I may adhere to the name *Sporangites*, which, though not chnically correct, when applied to the individual macrospores, is suf- iently accurate when taken in connection with their occurrence in oups surrounded by cellular Sporocarps. Its priority and its use (since 65) also give it claims to consideration. It will therefore be understood at when I use this term I refer to macrospores like those of the Lake uron shale, as well as to Sporocarps containing macrospores, as in the azilian specimens. The equivalent term *Protosalvinia* I shall use as a ospective name to be applied to the whole plant so soon as this shall be own.

Since the publication of my paper on Rhizocarps in the Palaeozoic riod above referred to, I have received two papers from Mr. Edward ethered, F. G. S., in one of which he describes spores of plants found the Lower Limestone shales of the Forest of Dean, and in the other cusses more generally the structure and origin of Carboniferous Coal ds.[*] In both papers he refers to the occurrence in these coals and ales of organisms essentially similar to the Erian spores.

In the Bulletin of the Chicago Academy of Science, January, 1884, . Johnson and Mr. Thomas, in their paper on the Microscopic Organ- ns of the Boulder Clay of Chicago and vicinity, notice *Sporangites uronensis* as among these organisms, and have discovered them also in rge numbers in the precipitate from Chicago city water supply. They fer them to the decomposition of the Erian shales, of which boulders led with these organisms are of frequent occurrence in the Chicago ays. The Sporangites and their accompaniments in the boulder clay e also noticed in a paper by Dr. G. M. Dawson, in the Bulletin of e Chicago Academy, June, 1885.

Prof. Clarke has also described, in the American Journal of ience for April, 1885, the forms already alluded to and which he finds consist of Macrospores enclosed in Sporocarps. He compares these h my *Sporangites Huronensis* and *Protosalvinia bilobata*, but I think s likely that one of them at least is a distinct species.

I may add that in the Geological Magazine for 1875, Mr. Newton, G. S., of the Geological Survey, of England, published a description the Tasmanite and Australian white coal, in which he shows that the anisms in these deposits are similar to my *Sporangites Huronensis*, and the Macrospores previously described by Prof. Huxley, from the Better- l coal. Mr. Newton does not seem to have been aware of my previous cription of *Sporangites*, and proposes the name, *Tasmanites punctatus*, for Australian form.

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[*] Cotteswold Naturalists' Field Club, 1884. Journal of Royal Microscopical Society, 1885.

Mr. R. Kidston, F. G. S., has recently been engaged in the examination of the spores and sporangia contained in Devonian and Carboniferous deposits in Scotland, and some of which, as he informs me, are similar to those referred to in this paper; but I have not yet seen his published results.

To the kindness of Mr. Thomas I am indebted for a large series of microscopic preparations of these fossils, and of others in the Bedford shale of Ohio, prepared from specimens sent to him by Prof. Orton, the results of the microscopic examination of which I propose to notice, and to inquire as to the inferences which are now warranted respecting the affinities of these organisms.

II.—DESCRIPTION OF THE SPECIMENS.

The typical macrospores from the Erian shales are perfectly circular in outline, and in the flattened state appear as discs with rounded edges, their ordinary diameter being from 1-75th to 1-100th of an inch, though they vary considerably in size. This, however, I do not regard as an essential character. The edges, as seen in profile, are smooth, but the flat surface often presents minute dark spots, which at first, I mistook for papillæ; but now agree with Mr. Thomas in recognizing them as minute pores traversing the wall of the disc, and similar to those which Mr. Newton has described in Tasmanite, and which Mr. Wethered has also recognized in the similar spores of the Forest of Dean shales. The walls also sometimes show faint indications of concentric lamination, as if they had been thickened by successive deposits.

As seen by transmitted light, and either in front or in profile, the discs are of a rich amber color, translucent and structureless, except the pores above referred to. The walls are somewhat thick, or from $\frac{1}{10}$th to $\frac{1}{20}$th the diameter of the disc in thickness. They never exhibit the triradiate marking seen in spores of Lycopods, nor any definite point of attachment, though they sometimes show a minute elongated spot which may be of this nature, and they are occasionally seen to have opened by slits on the edge or front, where there would seem to have been a natural line of dehiscence. The interior is usually quite vacant or structureless, but in some cases there are curved internal markings which may indicate a shrunken lining membrane, or the remains of a prothallus or embryo. Occasionally a fine granular substance appears in the interior, possibly remains of microspores.

The discs are usually detached and destitute of any envelope, but usually fragments of flocculent cellular matter are associated with them, and in one specimen from the corniferous limestone of Ohio, in Mr. Thomas' collection, I have found a group of eight or more discs partly enclosed in a cellular sac-like membrane of similar character to that enclosing the Brazilian specimens already referred to.

The characters of all the specimens are essentially similar, and there is a remarkable absence of other organisms in the shale. In one instance only, I have observed a somewhat smaller round body with a dark centre or nucleus, and a wide translucent margin, marked by a slight granulation. Even this, however, may indicate nothing more than a different state of preservation.

It is proper to observe here that the wall or enclosing sac of these macrospores must have been of very dense consistency, and now appears as a highly bituminous substance; in this agreeing with that of the spores of Lycopods, and like them, having been when recent of a highly carbonaceous and hydrogenous quality, very combustible and readily admitting of change into bituminous matter. In the paper already referred to, on spore-cases in coals, I nave noticed that the relative composition of lycopodium and cellulose is as follows:

Cellulose $C_{24}\ H_{20}\ O_{20}$

Lycopodium $C_{42}\ H\ 19\frac{4}{12}\ N\ O\ 5\ \frac{6}{10}$.

Thus, such spores are admirably suited for the production of highly carbonaceous or bituminous coals, etc.

Nothing is more remarkable in connection with these bodies than their uniformity of structure and form over so great areas and throughout so great thickness of rock, and the absence of any other kind of spore-case. This is more especially noteworthy in contrast with the coarse coals and bituminous shales of the carboniferous, which usually contain a great variety of spores and sporangia, indicating the presence of many species of acrogenous plants, while the Erian shales on the contrary indicate the almost exclusive predominance of one form. This contrast is well seen in the Bedford shales overlying these beds, and I believe Lower Carboniferous.* Specimens of these have been kindly communicated to me by Prof. Orton, and have been prepared by Mr. Thomas. In these we see the familiar carboniferous spores with triradiate markings called *Triletes* by Reinsch, and which are similar to those of Lycopodiaceous plants. Still more abundant are those spinous and hooked spores or sporangia, to which the names *Sporocarpon*, *Zygosporites* and *Traquaria* have been given, and some of which Williamson has shown to be spores of Lycopodiaceous plants.†

The true "Sporangites" on the contrary are round and smooth, with thick bituminous walls, which are punctured with minute transverse pores. In these respects, as already stated, they closely resemble the bodies found in the Australian white coal and Tasmanite. The precise geological age of this material is not known with certainty, but it is believed to be Palaeozoic.

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* According to Newberry, lower part of Waverly group.

† *Traquaria* is to be distinguished from the calcareous bodies found in the corniferous limestone of Kelly's Island, which I have described in the Canadian Naturalist as *Saccamina eriana*, and believe to be Foraminiferal tests. See Dr. Williamson's papers in transactions of Royal Society of London.

III.—MODE OF OCCURRENCE OF SPORANGITES, AND ITS BEARING ON THEIR ORIGIN.

Under this head we may note first the great abundance and wide distribution of these bodies. The horizontal range of the bed at Kettle Point is not certainly known, but it is merely a northern outlier of the great belt of Erian shales referred to by Prof. Orton, and which extends, with a breadth of ten to twenty miles, and of great thickness, across the State of Ohio, for nearly 200 miles. This Ohio black shale, which lies at the top of the Erian or the base of the Carboniferous, though probably mainly of Erian age, appears to abound throughout in these organisms and in some beds to be replete with them. In like manner, in Brazil, according to Mr. Derby, these organisms are distributed over a wide area and throughout a great thickness of shale holding *Spirophyton*, and apparently belonging to the Upper Erian. The recurrence of similar forms in the Tasmanite and white coal of Tasmania and Australia is another important fact of distribution. To this we may add the appearance of these macrospores in coals and shales of the Carboniferous period, though there in association with other forms.

It is also to be observed that the Erian shales, and the Forest of Dean beds described by Wethered, are marine, as shown by their contained fossils; and though I have no certain information as to the Tasmanite and Australian white coal, they would seem, from the description of Milligan, to occur in distinctly aqueous, possibly estuarine, deposits. Wethered has shown that the discs described by Huxley and Newton in the Better-bed coal occur in the earthy or fragmentary layers as distinguished from the pure coal. Those occurring in cannel coal are in the same case, so that the general mode of occurrence implies water-driftage, since in the case of bodies so large and dense, wind-driftage to great distances would be impossible.

These facts, taken in connection with the differences between these macrospores and those of any known land plant of the Palaeozoic, would lead to the inference that they belonged to aquatic plants, and these vastly abundant in the waters of the Erian and Carboniferous periods.

It is still further to be observed that they are not, in the Erian beds, accompanied with any remains of woody or scalariform tissues such as might be expected in connection with the debris of terrestrial acrogens, and that, on the other hand, we find them enclosed in cellular sporocarps, though in the majority of cases these have been removed by dehiscence or decay.

These considerations, I think, all point to the probability which I have suggested in my previous paper on this subject, that we have in these objects the organs of fructification of plants belonging to the order *Rhizocarpeæ*, or akin to it. The comparisons which I have instituted with the porocarps and macrospores of these plants confirm this suggestion. Of he modern species which I have had an opportunity to examine, *Salvinia atans* of Europe perhaps presents the closest resemblance. In this plant roups of round cellular sporocarps appear on the surface of the floating ronds. They are about a line in diameter when mature, and are of two inds, one containing macrospores, the other microspores or antheridia. The first, when mature, hold a number of closely packed globular or oval porangia of loose cellular tissue attached to a central placenta. Each of hese sporangia contains a single macrospore, perfectly globular and mooth, with a dense outer membrane (exhibiting traces of lamination, and howing within an irregularly vacuolated or cellular structure, probably a rothallus). I can not detect in it the peculiar pores which appear in the ossil specimens. Each macrospore is about one-seventieth of an inch in liameter when mature. The sporocarps of the microspores contain a astly greater number of minute sporangia, about one two-hundredths of n inch in diameter. These contain disc-like antheridia, or microspores f very minute size.

The discs from Kettle Point and from the Ohio black shale, and from he shale boulders of the Chicago clays, are similar to the macrospores of *alvinia*, except that they have a thicker wall and are a little less in diamter, being about one-eightieth of an inch. The Brazilian sporocarps are onsiderably larger than those of the modern Salvinia, and the macropores approach in size to those of the modern species, being one-seventy-fth of an inch in diameter. They also seem, like the modern species, to ave thinner walls than those from Canada, Ohio and Chicago. No listinct indication has been observed in the fossil species of the inner porangium of *Salvinia*. Possibly it was altogether absent, but more robably it is not preserved as a distinct structure.

With reference to the microspores of Salvinia, it is to be observed that he sporocarps, and the contained spores or antheridia, are very delicate nd destitute of the dense outer wall of the macrospores. Hence such arts are little likely to have been preserved in a fossil state; and in the Erian shales, if present, they probably appear merely as flocculent carbonceous matter not distinctly marked, or as minute granules not well lefined, of which there are great quantities in some of the shales.

The vegetation appertaining to the Sporangites has not been distinctly ecognized. I have, however, found in one of the Brazilian specimens wo sporocarps attached to what seems a fragment of a cellular frond, nd numerous specimens of the supposed Algæ, named *Spirophyton*, are ound in the shales, but there is no evidence of any connection of this lant with the Protosalvinia.

Modern Rhizocarps present considerable differences as to their vegeative parts. Some, like *Pilularia*, have simple linear leaves; others, like

Marsilea, have leaves in verticils and cuneate in form; while others, like *Azolla* and *Salvinia*, have frondose leaves, more or less pinnate in their arrangement. The first type presents little that is characteristic, but there are in the Erian sandstones and shales great quantities of filamentous and linear objects which it has been impossible to refer to any genus, and which might have belonged to plants of the type of *Pilularia*. It is quite possible, also, that such plants as *Psilophyton glabrum* and *Cordaites angustifolia*, of which the fructification is quite unknown, may have been allied to Rhizocarps. With regard to the verticillate type, we are at once reminded of *Sphenophyllum*, which many palæo-botanists have referred to the *Marsiliaceæ*, though like other Palæozoic Acrogens, it presents complexities not seen in its modern representatives, *S. primævum* of Lesquereux is found in the Hudson River group, and my *S. antiquum* in the Middle Erian. Besides these, there are in the Silurian and Erian beds plants with verticillate leaves which have been placed with the Annulariæ, but which may have differed from them in fructification. *Annularia laxa*, of the Erian, and *Protannularia Harknessii*, of the Silurio-Cambrian, may be given as examples, and must have been aquatic plants, probably allied to Rhizocarps. It is deserving of notice, also, that the two best known species of Psilophyton (*P. princeps* and *P. robustius*), while allied to Lycopods by the structure of the stem and such rudimentary foliage as they possess, are also allied, by the form of their fructification, to the Rhizocarps, and not to ferns, as some palæo-botanists have incorrectly supposed.

The curious plants known as *Arthrostigma*, seem also to have been allied to Psilophyton in their fruit, though bearing it in spikes instead of as separate sporocarps.*

I would also here direct attention to those pinnate leaves from the Erian and Carboniferous, which I have named *Ptilophyton*, and to those from the Carboniferous, which Lesquereux has named *Trochophyllum*. I have fully discussed the structure of these in my Report of 1882 on the Erian Plants of Canada, and may here merely state that I have shown that they were aquatic plants, probably bearing sporocarps attached to their stems somewhat in the manner of *Azolla*.

The whole of this evidence, I think, goes to show that in the Erian period there were vast quantities of aquatic plants allied to the modern Rhizocarps, and that the so-called Sporangites referred to in this paper were probably the drifted sporocarps and macrospores of some of these plants or of plants allied to them in structure and habit, of which the vegetative organs have perished. I have shown that in the Erian period there were vast swampy flats covered with *Psilophyton*, and in similar submerged tracts near to the sea the *Protosalvinia* may have filled the waters and have given off the vast multitudes of Macrospores which drifted by currents have settled in the mud of the black shales.

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* Report on Erian Plants of Canada, Part II, 1882.

III.—CLASSIFICATION OF SPORANGITES.

It is, of course, very unsatisfactory to give names to mere fragments of plants, yet it seems very desirable to have some means of arranging them. With respect to the organisms of the present paper, which were originally called by me *Sporangites*, under the supposition that they were Sporangia rather than Spores, this name has so far been vindicated by the discovery of the spore-cases belonging to them, so that I think it may still be retained as a provisional name; but I would designate the whole as *Protosalviniæ*, meaning thereby plants with Rhizocarpean affinities, though possibly when better understood belonging to different genera. We may under these names speak of their detached discs as macrospores and of their cellular envelopes as sporocarps. The following may be recognized as distinct forms.

1.—*Protosalvinia Huronensis*, Dawson, Syn., Sporangites Huronensis, Report on Erian Flora of Canada, 1871.—Macrospores in the form of discs or globes, smooth and thick-walled, the walls penetrated by minute radiating pores. Diameter about $\frac{1}{100}$th of an inch or a little more. When in situ several macrospores are contained in a thin cellular sporocarp, probably globular in form. From the Upper Erian, and perhaps Lower Carboniferous shales of Kettle Point, Lake Huron, of various places in the State of Ohio, and in the shale boulders of the boulder clay of Chicago and vicinity. First collected at Kettle Point by Sir W. E. Logan, and in Ohio by Prof. Edward Orton, and at Chicago by Dr. H. A. Johnson and Mr. B. W. Thomas, also in New York by Prof. J. M. Clarke.

The macrospores collected by Mr. Thomas from the Chicago clays and shales conform closely to those of Kettle Point, and probably belong to the same species. Some of them are thicker in the outer wall, and show the pores much more distinctly. These have been called by Mr. Thomas *S. Chicagoensis*, and may be regarded as a varietal form. Specimens isolated from the shale and mounted dry, show what seems to have been the hilum or scar of attachment better than those in balsam.

Sections of the Kettle Point shale show, in addition to the Macrospores, wider and thinner shreds of vegetable matter, which I am inclined to suppose to be remains of the Sporocarps.

2.—*Protosalvinia* (*Sporangites*) *Braziliensis*, Dawson, Can. Rec. of Sci., 1883.—Macrospores, round, smooth, a little longer than those of the last species, or about $\frac{1}{78}$th of an inch in diameter, enclosed in round, oval or slightly reniform sporocarps, each containing from four to twenty-four macrospores. Longest diameter of sporocarps three to six millimeters. Structure of wall of sporocarps hexagonal cellular. Some sporocarps show no macrospores, and may possibly contain microspores. The specimens are from the Erian of Brazil. Discovered by Mr. Orville Derby. The formation, according to Mr. Derby, consists of black shales below, about

300 feet thick, and containing the fucoid known as Spirophyton, and probably decomposed vegetable matter. Above this is chocolate and reddish shale in which the well preserved specimens of *Protosalvinia* occur. These beds are very widely distributed and abound in *Protosalvinia* and *Spirophyton.*

3.—*Protosalvinia* (*Sporangites*) *bilobata*, Dawson, Can. Rec. of Science, 1883.—Sporocarps, oval or reniform, three millimeters to six millimeters in diameter, each showing two rounded prominences at the ends, with a depression in the middle, and sometimes a raised neck or isthmus at one side connecting the prominences. Structure of sporocarp cellular. Some of the specimens indicate that each prominence or tubercle contained several macrospores. At first sight it would be easy to mistake these bodies for valves of *Beyrichia.*

Found in the same formations with the last species, though in so far as the specimens indicate, not precisely in the same beds. Collected by Mr. Derby.

4.—*Protosalvinia Clarkei*, Dawson, P. bilobata, Clarke, Am. Jl. of Science.—Macrospores ⅔ to 1 millimeter in diameter. One, two or three contained in each sporocarp, which is cellular. The macrospores have very thick walls with radiating tortuous tubes. Unless this structure is a result of mineral crystallization, these macrospores must have had very thick walls and must have resembled in structure the thickened cells of stone fruits and of the core of the pear, or the tests of the Silurian and Erian seeds known as *Pachytheca*, though on a smaller scale.

It is to be observed that bodies similar to these occur in the Boghead earthy bitumen and have been described by Credner.

I have found similar bodies in the so-called " Stellar coal " of the coal district of Pictou, Nova Scotia, some layers of which are filled with them. They occur in groups or patches, which seem to be enclosed in a smooth and thin membrane or sporocarp. It is quite likely that these bodies are generically distinct from *Protosalvinia.*

5.—*Protosalvinia punctata*, Newton, Geol. Mag. N. S. Dec. 2, vol. II. Mr. Newton has named the discs found in the white coal and Tasmanite, *Tasmanites*, the species being *Tasmanites punctatus*, but as my name Sporangites had priority, I do not think it necessary to adopt this term, though there can be little doubt that these organisms are of similar character. The same remark may be made with reference to the bodies described by Huxley and Newton as occurring in the Better-bed coal.

V.—GENERAL REMARKS.

It may be well to mention here the various characters of pyroschists r bituminous shales of different ages, as they have come under my notice.

The Utica shale of Collingwood, Ontario, which has been used for the istillation of coal oil, shows under the microscope only flocculent matter nd slender spicules, and its bitumen seems to have been derived from the isintegration of algæ and zoophytes.

A specimen of inflammable shale from the Trenton of Minnesota, preared by Mr. Thomas, shows similar shreds of organic matter without ny macrospores.

Bituminous shales associated with a small layer of coal in the middle Erian of Gaspe, show great quantities of shreds of epidermal tissue and ragments of the chitinous crusts of Eurypterids, but no distinct macropores.

The richly bituminous shales of the Lower Carboniferous of Albert ounty, New Brunswick, which have furnished the material of the Alberite or hardened bitumen of that district, have not afforded any macropores in the specimens I have been able to examine, but are filled with hreds apparently of vegetable matter in a much disintegrated state.

The Bedford shales of Ohio contain, in addition to fragments of pidermal and woody and vascular tissue, many forms of macrospores uite distinct from those of the underlying Erian shales. A similar reark may be made as to many varieties of coarse coal, cannel coal and ituminous shale of the coal measures, in which many forms of macrospores nd sporangia may be found mixed with shreds of the more durable tissues, nd especially of the epidermal tissue of various kinds of plants. Dr. Newberry and Mr. Julian have described in the Annals of the N. Z. Academy of Science, 1883, a number of specimens of bituminous shales ot containing Sporangites, and Dr. Newberry refers the bituminous mater to the decomposition of algæ, or in some cases to that of miscellaneous egetable débris from the land, a conclusion which he has applied also to he cannel coals.

From these facts it would appear that the presence of Rhizocarpean acrospores is not a necessary condition of the formation of bituminous hales, earthy bitumens or coals. Yet it seems certain that the macropores are the cause of the highly bituminous character of the shales which re charged with them. On the other hand, many highly bituminous hales, such as, for instance, some beds of the Utica shale and the Lower Carboniferous shales of Albert county, New Brunswick, depend for their nflammable matter on microscopic débris of an entirely different character.

In point of fact* any kind of epidermal or dense cortical tissue has chemical properties not very dissimilar from those of the tests of macrospores; and such tissues have, as I have elsewhere shown,† been mainly instrumental in the production of coal, in some layers of which, however, macrospores and sporangia occur in large quantity. In regard to strictly marine shales, while it is probable or suggested by Newberry, that algæ may have furnished the material of much of the bituminous matter, I confess I am inclined to attach some importance in this respect to the corneous substance of Graptolites and other Zoophytes, which is nearer in composition to corky and epidermal matter.

In a botanical point of view the facts stated in this paper show that in the Erian, and probably also in the Carboniferous age, the type of plants now represented by the Rhizocarps was very largely developed, and that the macrospores of these plants were produced in such abundance as to charge great thicknesses of shales over very large areas with these bodies, which, owing to the density and indestructible character of the outer test, have resisted decomposition and remain unmineralized in the mass, giving to it the same highly combustible character which would result from the mixture of a like amount of Lycopodium spores with similar sediment.

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*See my paper on Spore-cases in Coal. American Journal of Science, 1871.

†Journal of Geol. Society of London, 1865, and American Journal of Science, 1871. Also Acadian Geology, 1878.

Description of Figures.

Figure 1. Protosalvinia (sporangites) Braziliensis, sporocarps and spores, nat. size. 1a, 1b, same enlarged; 1c, cellular tissue of sporocarp much magnified.

Figure 2. P. (sp.) bilobata, nat. size.

Figure 3. Salvinia natans, modern, sporocarps, nat. size.
3a. Sporocarp with macrospores enlarged.
3b. Macrospores with sporangium, × 80.
3c. Sporangium with microspores × 80.
3d. Wall showing lamination.

Figure 4. P. (sp.) Huronensis, macrospore × 80, showing pores, 4a, 4b, portions of wall more magnified.

Figure 5. P. (sp.) Huronensis, showing hilum and internal granular matter × 80.

Figure 6. P. (sp.) Huronensis with thickened wall × 80, 6a, nat. size.

Figure 7. P. (sp.) Huronensis, group with remains of sporocarp; Corniferous Limestone. × 40. 7a cellular tissue of sporocarp highly magnified.

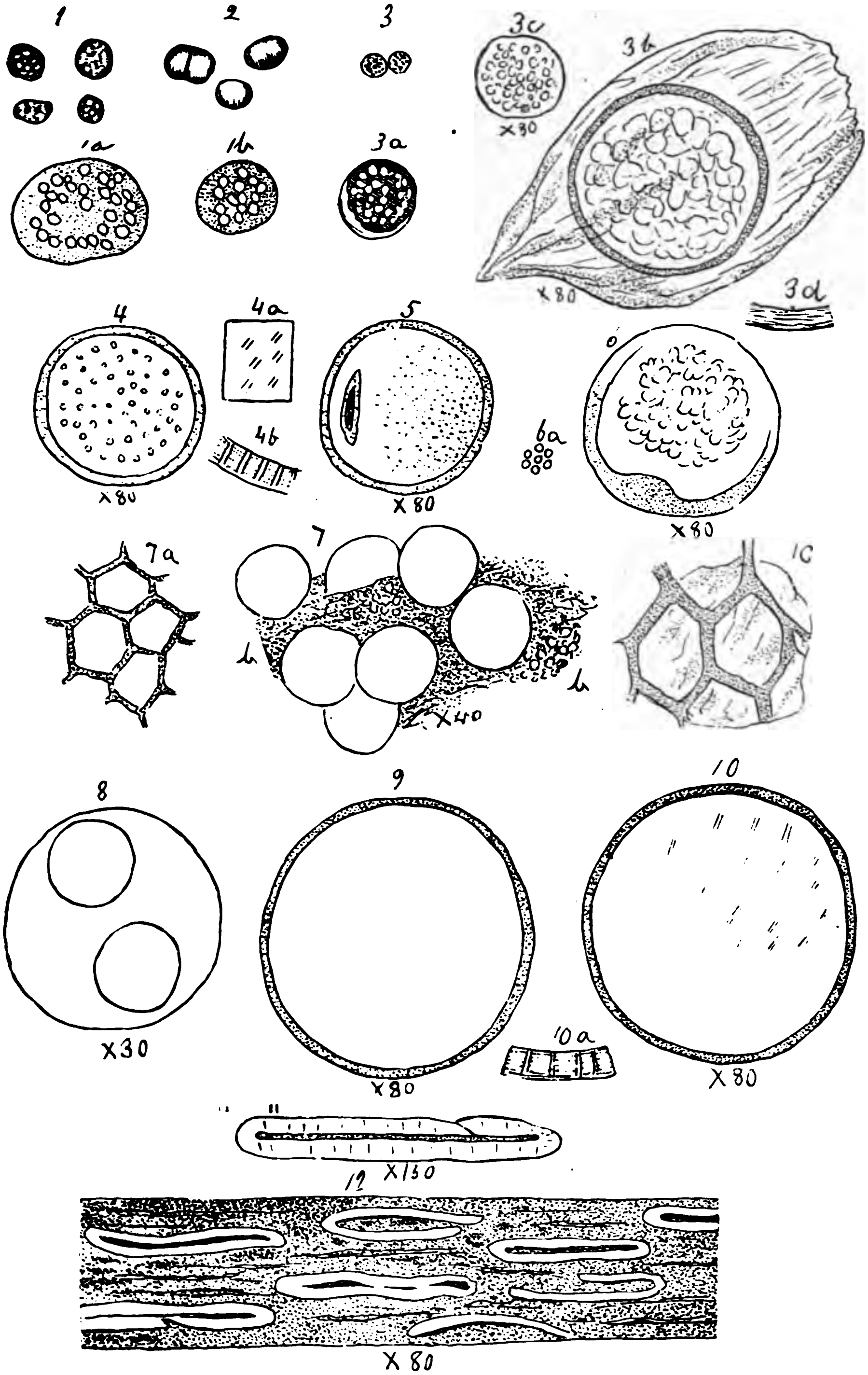
Figure 8. P. Braziliensis, sporocarp and 2 macrospores, outline, × 30.

Figure 9. P. Braziliensis, Macrospore ×.

Figure 10. P. (Tasmanites) punctatus, × 80, showing pores; 10a, wall highly magnified, showing pores.

Figure 11. P. (sp.) Huronensis, Section × 150.

Figure 12. Shale from Kettle Point, showing flattened macrospores and remains of sporocarps, × 80.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Vol. I. *No. X.*

BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCE.

A PAPER ON

Elephas Primigenius.

BY W. K. HIGLEY, Ph.D.

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BULLETIN

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CHICAGO ACADEMY OF SCIENCE.

ELEPHAS PRIMIGENIUS.

By W. K. Higley, Ph. D.

(Read at October Meeting, 1886.)

During the past summer the Academy Museum has been enriched.by a ounted specimen of that enormous animal of past ages, the mammoth, *'lephas primigenius.*

For this addition to our collection we are indebted to our President, r. Edmund Andrews, who with much labor kept the skeleton in view r many years, till the price was reduced to a reasonable sum, when he terested the following gentlemen in the matter, who, with himself, pur-ased the bones and presented them to the Academy: Hon. Wm. Bross, hilip D. Armour, John Crerar, Norman Williams, Joseph Frank, Wirt exter, Hamilton B. Bogue and the members of the Mastodon Club. Thus, the kindness of these gentlemen the Academy comes into possession of e only bones, I believe, ever found in this country in a sufficient state of eservation or numbers to permit of mounting.

Inspection proved that these remains were not only worthy of our atten-n in the unmounted state, but also that they were in such a condition that ey could, by restoring certain parts, be placed in their natural position. was deemed wise to mount them, for in this condition they would be uch more instructive. This was attempted and for the grand result of the fort, which stands in the museum, the second mounted mammoth in the rld, the Academy is indebted to Dr. J. W. Velie, assisted by Messrs. J. Hancock, Kuh, C. S. Babcock and Dr. Wyllys Andrews. These gentle-en volunteered their services and worked arduously and skillfully for the eater part of two months.

The bones were found in the spring of 1878, in the southwest part of okane County, Wash., on the farm of a Mr. Copelin. The country is a lling prairie, about 2,100 feet above the sea, extending from the Rocky ountains to the Cascade Range. The water-courses are timbered, the rest eless. The soil is a rich black loam with white clay subsoil. Hangman's Creek, about 350 feet wide, runs through this part of the county into the Spokane River, which is a tributary of the Columbia. The prairie is an excellent grain land, and in the wild state produces grass thirty inches high.

The remains of four mammoths were found on the upland in a marshy hollow, about fifty feet in diameter, formed by a spring oozing out of the black mud, whose waters flowed off in a narrow valley to Hangman's Creek, about three-fourths of a mile distant. The bones were exposed while ditching in order to drain the spot.

A very perfect skeleton of a smaller animal, supposed, by a gentleman who saw it, to be a horse, was exposed with the mammoth bones. It is worthy of note that in this spring-hole cattle and other animals were occasionally mired.

Neither of the four skeletons found was complete, and in mounting, it was not always possible to tell one individual from another. Besides the four adult skeletons, there was a fragment of a small pelvis, probably from a fœtus of one of the female mammoths dying pregnant.

The following is a list of bones found:

3 lower jaws, with teeth perfect.
13 cervical vertebræ.
20 dorsal vertebræ.
4 lumbar vertebræ.
9 caudal vertebræ.
1 sacrum.
2 pelves, one entire, and one supposed fœtal fragment.
3 scapulas.
2 femurs, one a fragment.
1 patella.
1 ulna, a fragment.
2 humeri, one a fragment, and the other from another locality.
6 tusks.
7 upper molars and fragments.
32 ribs.
1 skull, merely some small fragments.
14 bones of the feet.

Thus the total number of bones, or their fragments, found was 121.

The total weight of the bones was about 700 pounds.

It will be noticed that the most important bones needed in making the measurements necessary for supplying the lost parts, in the process of restoration, were present. The work of restoration was done with conscientious care, using, when necessary, the bones of one of the smaller animals as patterns in modeling for the larger. In a few cases the bones of the *Elephas Indicus*, which are almost identical in form, served as patterns.

The height as it stands is 13 feet, while that of the St. Petersburg ammoth is only 9 feet 3 inches.

It will be of interest to compare the height of a few elephantine forms.

Jumbo's skeleton, *Elephas Africanus*, is 10 feet 3 inches; Warren's *Mas- don giganteus*, at Boston, is 11 feet, and the Hauser *Elephas Indicus* at orthwestern University, Evanston, Ill., is 10 feet 8 inches.

If we allow two inches for the gristly cushion under the feet, and three ches for the thickness of the flesh on its back, and some few inches for the ol and bristly mane, which is said to have crested the spine in the St. tersburg specimen, it would seem that this animal, when living, must have en about 14 feet in height.

Some elephantine bones of great size have been reported from our west- n territories and attributed to *Elephas imperator*. If there is any ade- ate proof of such a species, our enormous specimen doubtless belongs to but the great size is not sufficient to prove a separate species when three aller individuals were found in the same small area. Besides, the tusks ve the peculiar and strong curve characteristic of the *Elephas primi- nius*, and not known in any other elephant. The tusks were 9 feet 10 in- es long measured on the outer curvature.

The teeth also correspond with those of the mammoth.

The following are some measurements of true bones in the mounted skele- n:

Length of tusk, 9 feet 10 inches.
Circumference of tusk at the base, 21 inches.
Number of laminæ of lower teeth, 19.
Breadth of lower teeth, 3½ inches.
Length of lower teeth, 10 inches.
Breadth of lower jaw at the condyles, 23 inches.
Length of lower jaw, 22 inches.
Breadth of atlas, 18 inches.
Height of atlas, 9½ inches.
Height of pelvis, 34 inches.
Breadth of pelvis, 62 inches.
Height of scapula, 39 inches.
Breadth of scapula, 25 inches.
Length of humerus, 45 inches.
Circumference of humerus at middle of shaft, 19 inches.

Dana says: "This ancient elephant was over twice the weight of the gest modern species, and nearly a third larger. The body was covered th a reddish wool and long black hair. One of the tusks measured 12½ t in length; it was curved nearly into a circle, though a little obliquely. * * At the mouth of the Lena one of these animals was found, at the inning of this century, frozen and encased in ice. It measured 16 feet

4 inches in length to the extremity of the tail, exclusive of the tusks, and 9 feet 4 inches in height. It retained the wool on its hide, and was so perfectly preserved that the flesh was eaten by the dogs." [Manual of Geology, p. 565.]

So far as I am able to find, the species in Europe does not, on the average, exceed the stature of the living elephants, but this may be an error, or it may be that the climate and soil of our Western mountains and plains favored a larger stature in the species than in Siberia and Europe.

Perhaps at this point it would not be out of place to mention the "Lenape Stone," which has been made the subject of an exhaustive study by Mr. H. C. Mercer. This stone was found in Bucks County, Penn., in 1872. It has given rise to considerable discussion concerning its authenticity. A drawing on the stone represents the Indians in battle with the "hairy mammoth." Mr. Mercer holds that this is evidence indicating that the mammoth was contemporaneous with the American Indians. He believes in its authenticity, and has collected considerable evidence supporting his opinions, giving them to the public in a monograph published by G. P. Putman's Sons.

The spring-hole, in which the mammoth remains were found, was about 6 or 8 miles from a range of the Rocky Mountain system which separates the prairie country from Lake Coeur d'Alene. These mountains are heavily timbered everywhere. The habits of all the wild animals there is to keep to the mountains in the summer, but to retire to the prairie at the approach of winter, and the following spring to follow the receding snow up the mountain side again. Probably the mammoth did likewise. Prof. Baird says mammalian animals in general are taller and larger in proportion as their habitat is well north or in mountainous regions. This, with good food, may have resulted in an enormous growth. It may be that the grass on the fertile prairie, growing very luxuriantly, may have served as a food.

The mammoth, and in fact all elephantine remains, are usually found in groups composed of two or more individuals. At least four animals were entombed in one spot at the locality where the Academy specimen was found. Our former Director, Robert Kennicott, reported that in Alaska the bones of this species sometimes lie in clusters of several individuals. The Indians informed him of a valley where immense numbers of elephantine bones lay due, as they supposed, to a great battle among supernatural beings.

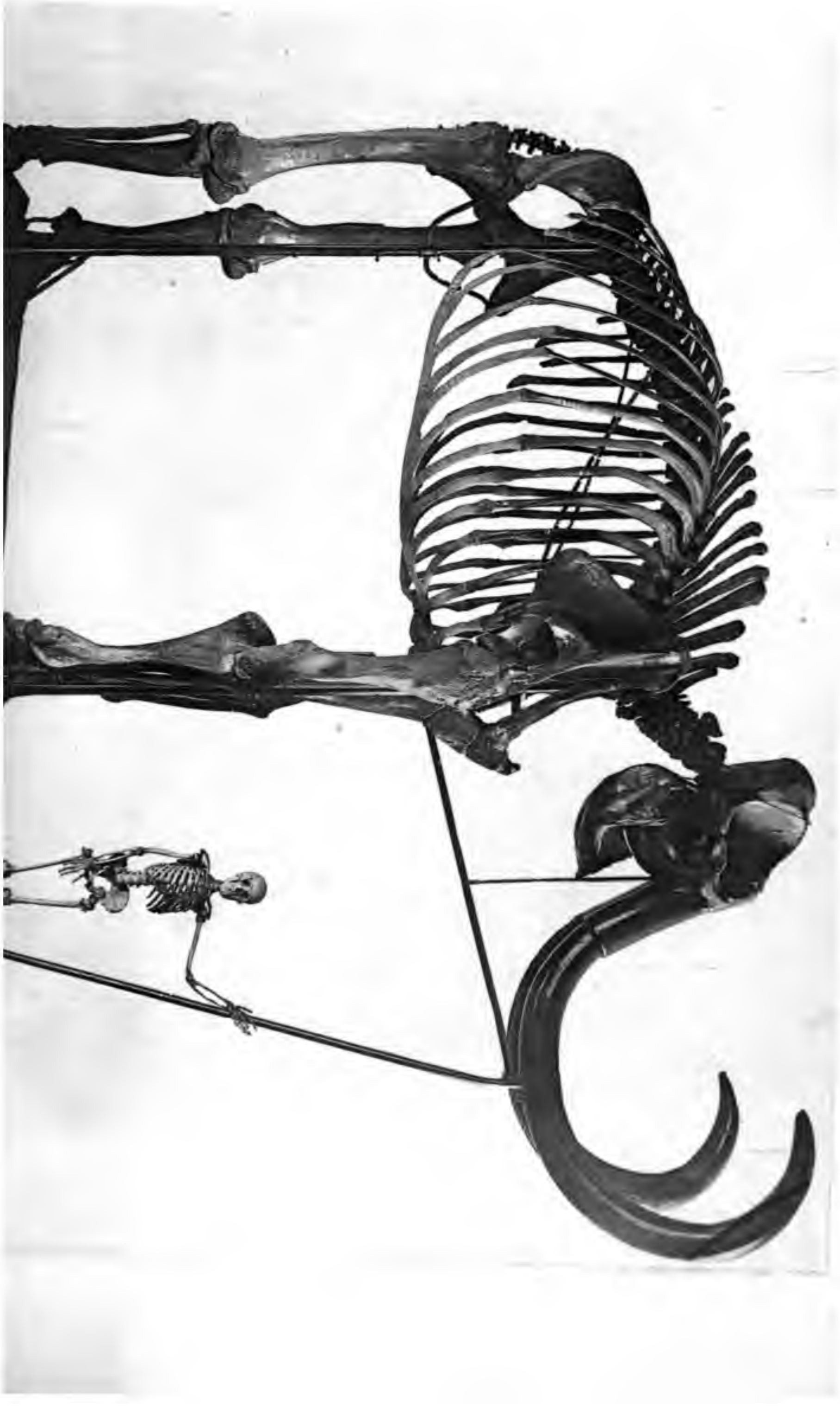
Dr. Stimpson exhumed, at Fort Wayne, Ind., three mastodons from one spot. In the island of Malta the extinct elephants are said to be huddled together in the upper valleys. It is thought by some that they were driven up by a submergence, and perished in groups in consequence.

The natives around the elephant lands of Hindostan think that the animals are in the habit of resorting to certain spots, deep in the forest, when they feel the approach of death, and thus leave their bones in groups.

If vast numbers exist in elevated valleys we might naturally admit the heory of their being driven together by the submergence which enclosed he Siberian specimen in frozen mud; but when only three or four are ound together, we believe that the following theory is more plausible.

Animals, like men, when taken with fatal diseases, often suffer with hirst long after they have lost all desire for food and in fact have become o weak to travel after it. They might, therefore, be expected to loiter in d around their drinking places and to die there, one at a time, but ul-mately accumulating in numbers.

Prof. Marsh, of Yale, informed Dr. Andrews that he had an unmounted berian mammoth in the museum store-room. So far as we know, that one d ours are the only nearly complete skeletons in this country, and ours the ly mounted one.



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BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES.

Preliminary Outline

— OF A —

New Classification of the Family Muricidæ

— BY —

FRANK COLLINS BAKER
Secretary and Curator.

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BULLETIN

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ICAGO ACADEMY OF SCIENCES.

MINARY OUTLINE OF A NEW CLASSIFICATION OF THE FAMILY MURICIDÆ.

BY FRANK COLLINS BAKER.

r several years the writer has been accumulating data upon the natural classification of the Gastropod family æ. It has been thought desirable to place before students the results elucidated, and to invite their friendly criticism. all the groups of Prosobranchiate Mollusks, none are more to naturally classify than this family; the shells and soft e so similar in general form, that it is almost impossible to ble characters upon which to base a sound division into The divisions of most of the old writers are unnatural, been based on shell characters alone, and in many cases, e groups *Phyllonotus* and *Ocinebra*, there has been a hope- gling of several distinct forms. Most modern authors have the other extreme, and divided the family into a large of useless and ill-defined sections, which has only helped the group into still further confusion. The author's aim resent paper has been simply to place before malacologists line of a classification essentially modern and essentially . It can scarcely be hoped that all will agree with the ation here adopted; but it is hoped that it will be found ovement over previous systems.

e notes given under each group must not be taken for com- iagnoses. Only the principle characters are given. In ing the genera and subgenera, the following characters must be taken into account: form of the [illegible], whether with varices or simple thickenings; of siphonal [illegible] of *operculum* and position of nucleus; form of [illegible], length of proboscis, shape of tentacles and position of [illegible]; character of the *lingual ribbon*, number and position of teeth and denticles.

It is an astonishing fact that of the six hundred and odd valid species of the family scarcely ten per cent have been examined for the animal and dentition. It may not be out of place to call attention right here to the manner of extracting and mounting the lingual ribbon, as there are a large number of species in which this organ is not known, and knowledge on this subject is much needed. This ribbon, also called the radula, is a strap or belt of chitinous or horny matter occupying the place in the mouth of the animal analogous to that occupied by the tongue in the vertebrates. The front end of the radula is secreted by a glandular [illegible] in a pouch which lies under and behind the [illegible] mass upon which the ribbon is [illegible]. The [illegible] of the ribbon is attached to the cuticle. The surface of the radula is set with teeth disposed in rows, transverse and longitudinal; the front rows differ only from those in the [illegible] as the first few rows are brought into active use, the rest [illegible] into use when the first [illegible]. The buccal mass is protrusible, and may be [illegible] crumbs of bread. In the larger forms the radula is [illegible] recognized, and can be dissected [illegible]. In most of the Murices it is found [illegible]. Some of the forms, as the [illegible] Purpuras, cannot be dissected [illegible] must be boiled in caustic potash. [illegible] the animal from its shell. [illegible] a tablespoonful of caustic [illegible] atmospheric moisture until it has [illegible] between a pair of forceps, and [illegible] lamp until it boils. [illegible] Be very careful that the [illegible] liquid [illegible] to the dry side of [illegible] by shaking the liquid [illegible] matter is dissolved; then it out quickly into a watch crystal, refill the test tube with r and pour into another watch crystal. Give the first crystal :ary motion, not too violent, so as to bring the solid particles ıe center. Examine with a powerful hand lens; a sheet of e paper under the watch crystal will greatly aid in discovering adula. This will be recognized by its curved, elongate shape apparently reticulated surface. If the radula is not found in irst crystal, examine the second. When found, in either one ie two crystals, transfer to a glass slide and examine under the oscope with powers ranging from one inch to one-eighth inch. ıd best be examined by transmitted light.

After examining and sketching the form of the radula, it will ecessary to tear the ribbon up so as to get separate rows and idual teeth, since they lie over one another like shingles on a The whole of one tooth cannot always be seen under one s, because the recurved cusps of the teeth are higher than the . When the teeth are very transparent, it will be found ssary to stain the radula. To do this, first carefully clean the la, then put it in a drop of strong solution of chromic acid; stains it yellowish brown. It may then be mounted tempo- y in glycerine jelly, or permanently in Canada balsam.

The teeth are disposed upon the radula in three principal itudinal rows, which are easily distinguished. There is always median longitudinal row of unpaired teeth, with a single row either side. The central tooth is called the median or *hidian* tooth. The teeth on either side are called *uncini*. In :ribing the teeth, note should be made of the form of the base ıttachment, especially in the rhachidian; also other special :acteristics such as simple, straight, curved or compound. h tooth (as the rhachidian) may be made up of a number of ections called cusps, and great care should be used in describ- and sketching these. In describing the teeth, we use a dental ıula to express the number and situation of the teeth and s; thus, if a radula has a single rhachidian and one uncinal h on each side, and the rhachidian tooth has five cusps, we ld express the formula as follows:

$$1 + \frac{1}{5} + 1.$$

The unit representing the tooth is written as a numerator and the number corresponding to the cusps as a denominator. In the example given, the uncini are long and prong-like and the cusp number is omitted. This is the case with all the Muricidæ. Careful drawings should always be made of both teeth and cusps, as well as accurate descriptions.

In describing the animal the following points should be carefully noted: shape and size of foot and position of operculum, with any peculiarities of same; shape of tentacles and position of eyes on same; size and shape of proboscis (if measurements are taken they should be in millimetres) size, shape, and position o verge (penis); color of animal, whether spotted or uncolored; size and shape of siphon occupying anterior canal. In the operculum the following points should be noted: size, shape and color, position of nucleus and surface sculpture, whether smooth or straight. In describing the shell, every point should be taken into consideration, such as size, number of varices, spiral and longitudinal sculpture, embryonic apex, size of aperture and condition of outer lip—simple, plicate, or dentate—anterior canal, whether long or short, open or closed, straight or curved; color, etc., etc.

In the following classification I have taken advantage of every character—shell, animal, operculum and radula. In my opinion, no one character can be picked out and used to the exclusion of all others, in any classification. Many of the older authors depended wholly upon conchological characters, and the result has not been at all satisfactory. In the following pages a number of groups are diagnosed in which some of the characters are not known (at least to me), and should any reader of this paper possess such information—either from original observation or from some publication unknown to me,[1] it would be greatly appreciated.

---

[1] The principal authorities consulted are the following:

Adams, H. & A., Genera of Recent Mollusca.

American Journal of Conchology.

Annals and Magazine of Natural History.

Baker, Frank C., Proc. Acad. Nat. Sci. Phil., 1889-1891.

Boston Journal of Natural History.

Bronn and Keferstein, Klassen und Ordnungen der Weichthiere.

Dall, W. K., numerous papers in Bull. Mus. Comp. Zool. Harvard College, and Proc. and Bull. U. S. Nat. Museum.

Primarily the Murices are divisible into three groups, as follows:

Shell canaliculate; whorls crossed by spinose or foliated varices; operculum ovate, with subapical or apical nucleus; verge narrow, club shaped, generally straight, but sometimes curved; dentition: the rhachidian tooth with but few cusps generally; formula as a rule, $1 + \frac{1}{5} + 1$.

SUBFAMILY I. MURICINÆ.

Shell with short canal or a simple notch; whorls ribbed, nodulous, or smooth; columella broad and flattened; operculum oblong, with lateral nucleus; verge thick, curved, tapering; dentition: the rhachidian tooth with (generally) numerous cusps, formula ranging from $1 + \frac{1}{3} + 1$ to $1 + \frac{1}{17} + 1$.

SUBFAMILY II. PURPURINÆ.

Shell with short canal; ribbed or frilled, scabrous; when adult free, or forming more or less irregular extensions of the outer and inner lips; living in coral; operculum ovate, nucleus sublateral, sometimes wanting; verge straight, swollen, club shaped; radula wanting (?)

SUBFAMILY III. CORALLIOPHILINÆ.

Fischer, Manual de Conchyliologie.

Journal de Conchyliologie.

Küster, Systematischen Conchylien Cabinet.

Lischke, Japanische Meeres Conchylien.

Malakozoologische Blätter.

Nachrichtsblatt der deutschen malakozoologischen Gesellschaft; also **ahrbücher** of the same.

Nouvelles Archives du Museum.

Proc. Royal Society of Tasmania.

" Linn Soc. New South Wales.

Say, Thomas, complete writings (By W. G. Binney.)

Troschel, Das Gebiss der Schnecken.

Tryon, Geo. W., Jr., Manual of Conchology.

Verrill, A. E., numerous papers in Trans. Conn. Acad. Sciences, and **eport** U. S. Fish Commission.

Watson, R. Boog, Mollusca of Challenger Expedition. In "Challenger **eports**."

Also numerous scattered papers in different Proceedings and Trans-**tions**.

SUBFAMILY I. MURICINÆ.

The principal characteristics of this group are, the spiny or nodulous varices and long canal: operculum with terminal initial point, a long. narrow, and club shaped verge, and a distinct muricoid dentition. There are, however, on the confines of this group, species which seem to partake of the characters of both *Murex* and *Purpura*, as certain forms of *Ocinebra*, *Urosalpinx* and *Trophon*. It is difficult, therefore. to draw up a diagnosis which will include all of one group to the exclusion of all others.

Genus MUREX Linné, 1758.

Shell ovate or oblong: spire always prominent, whorls rounded, crossed by three or more spinose or foliated varices; canal long or short, always distinct, partly open.

Animal with a large. broad foot; tentacles long and tapering, the eyes situated on the outside. near the end: proboscis cylindrical, long; verge long, club shaped. situated on the right side behind the tentacle.

Operculum ovate. with subapical nucleus.

Dentition $1 + \frac{1}{5} + 1$: the lateral cusps of the rhachidian tooth very large, the next two very small, and the central cusps very large; base of rhachidian tooth quadrate. uncini with single cusps, long and prong-like.

Type. MUREX TENUISPINA, Lam.

Subgenus MUREX (typical).

Shell more or less pyriform. spinose. with three varices; whorls rounded. crossed by distinct spiral lines: spire elevated; canal very long. nearly straight. partly closed: aperture ovate, the outer lip sometimes toothed.

Animal, *operculum* and *dentition* as in the genus.

Type. MUREX TENUISPINA, Lam.

Section HAUSTELLUM Klein., 1753.

Shell differs from Murex (typical) in the absence of spines, in the aperture being nearly circular. and in the canal being closed. Spire more compressed.

Animal, *operculum* and *dentition* as in the genus.

Type. MUREX HAUSTELLUM, Linné.

Subgenus BOLINUS[2] Peusch, 1837.

Shell ovate-pyriform, spinose, with six varices; whorls rounded, iral sculpture very fine; spire depressed; canal very long, straight, arly closed; aperture ovate, the outer lip simple; varices very large d strong.

Animal, operculum and *dentition* as in the genus.

Type. MUREX BRANDARIS, Linné.

Subgenus CHICOREUS Montf., 1810.

Shell ovate-pyriform, with three varices, foliated, seldom spinose; orls rounded, spiral sculpture generally very strong; spire elevated; al short, curved, wide, nearly or quite closed; aperture ovate, out- lip simple.

Animal, operculum and *dentition* as in the genus.

Type. MUREX PALMA-ROSÆ, Linné.

Subgenus HOMALOCANTHA Mörch, 1852.

Shell ovate-pyriform, with from five to eight varices; varices iated and produced into peculiar expanded digitations; whorls nded, sutures very deep; spire but little elevated; canal rather g, nearly straight and almost closed; aperture ovate, outer lip nulated.

Animal, operculum and *dentition* as in the genus.

Type. MUREX SCORPIO, Linné.

Subgenus PHYLLONOTUS Swainson, 1840.

Muricantha, Swanison, 1840.

Shell broadly-ovate, with from four to fifteen scaly or foliated rices; whorls rounded, spiral sculpture well developed; spire rang- from depressed to considerably elevated; canal of moderate length, ved, nearly closed; aperture ovate, outer lip crenulated.

Animal, operculum and *dentition* as in *Murex.*

Type. MUREX RADIX, Gmelin.

Subgenus PTERONOTUS Swainson, 1840.

Shell triangular, with three varices; varices fin-like or foliated; orls rounded; spire elevated; canal moderately straight or some- at curved, nearly closed; aperture oblong-ovate, the outer lip erally simple, but sometimes crenulated.

Animal, operculum and *dentition* as in the genus.

Type. MUREX PINNATUS, Wood.

---

[2] This name should take precedence over that of RHINOCANTHA, H. and A. Adams, published 53.

Genus EUPLEURA[3] H. and A. Adams, 1853.

Shell Ranelliform, with two lateral varices, and from four to twelve intermediate smaller varices; the lateral varices are sometimes not developed, and in these cases the shell is equi-varicose; varices foliated; whorls rounded; spire elevated; canal rather long, nearly straight, partly closed; aperture ovate, dentate within.

Animal with a short, rounded foot, truncate behind; tentacles long, tapering from base to tip, with the eyes about midway; verge on the right side, behind the tentacle, turned back in a curve, compressed at base, rounded and blunt at the tip.

Operculum like that of *Murex*.

Dentition $1 + \frac{1}{9} + 1$, the three lateral cusps of the rhachidian tooth very small, the three central cusps very large; the single-cusped uncini long, narrow and hooked.

Type. EUPLEURA CAUDATA, Say.

Genus XANTHOCHORUS[4] Fischer, 1884.

Shell broadly-ovate, thick, heavy; whorls rounded; varices numerous, fimbriated, crossed by from six to ten revolving ribs, the interstices crowded with incised revolving lines; spire not much elevated; canal very short, open, straight; umbilicus open; outer lip thick, dentate within.

Animal with a short, wide foot, rounded behind, truncate before; tentacles long, tapering from base to tip; eyes on prominences at the base of the tentacles; verge large and swollen, situated on the right side behind the tentacle; proboscis of medium size, cylindrical.

Operculum muricoid.

Dentition $1 + \frac{1}{3} + 1$; the three central cusps of the rhachidian tooth large and equal in size; uncini long, slender, pointed.

Type. XANTHOCHORUS XANTHOSTOMUS, Brod.

Genus FORRERIA[5] Jouss., 1880.

Shell pyriform, thick and heavy; whorls triangular, with numerous semi-foliated varices; no spiral sculpture; spire not much elevated; canal of moderate length, open, straight; umbilicus large, open; aperture long-ovate, outer lip with a tooth at the base.

Animal resembling that of *Purpura*.

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[3] In removing this genus from the vicinity of *Urosalpinx* to its present location, my position is fortified by the opinion of Mr. W. H. Hall, Mr. Chas. Simpson, and others. The shell is decidedly like *Pteronotus* and the operculum is the same as that of *Murex*.

[4] The thick and heavy shell, dentate lip and operculum, are, in my opinion, characters sufficiently marked to place this section in its present position as a genus.

Operculum purpuroid.

Dentition 1 + 1/3 + 1, the three cusps of the rhachidian tooth equal i size, triangular in shape, and very sharp, like the teeth of a saw; ncini curved and hook-like, very broad.

Type. FORRERIA BELCHERI, Hinds.

Genus TROPHON Montfort, 1810.

Shell fusiform or broadly-ovate, thick or thin, whorls rounded or ouldered; umbilicus open or closed; varices numerous, sharply ainated, the interstices smooth or spirally ribbed; spire usually vated, canal moderate, open, generally turned to the left; aperture long-ovate or rounded, outer lip thin or thick, smooth or dentate thin.

Animal with a short, rounded foot; tentacles long, tapering from se to tip, with the eyes situated on prominences near the base; oboscis of medium size, cylindrical.

Operculum of the purpuroid type, with an apical or sub-lateral cleus.

Dentition 1 + 1/7 + 1, 1 + 1/5 + 1, or 1 + 1/3 + 1, the central cusp the rhachidian tooth very large, and in the case of the five and ven cusped rhachidians, a large cusp alternates with a small one; ıcini long and fang-shaped.

Type. TROPHON GEVERSIANUS, Pallas.

Subgenus TROPHON (*sensu stricto*).

Shell broadly-ovate, rounded or strongly shouldered, with num-ous sharp, laminated varices, the interstices smooth or spirally bbed; spire elevated; canal short, open, nearly straight; aperture unded, outer lip simple, umbilicus open.

Animal as in the genus.

Operculum variable; the growth being lateral, causing the nucleus appear as if on the outer side instead of the lower extremity, thus sembling that of *Purpura*.

Dentition 1 + 1/3 + 1, the cusps of the rhachidian tooth very large d equal in size; uncini long and pointed.

Inhabits Antarctic seas.

Type. TROPHON GEVERSIANUS, Pallas.

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[a] This form has usually been classified under the genus *Chorus*, Gray. but the type of that us is the *Monoceras giganteum* of Lesson. It was placed in *Trophon* as a section by Fischer, I believe the better disposition to be as a separate genus, between *Xanthochorus* and phon.

Subgenus BOREOTROPHON Fischer, 1884.

Shell fusiform, rather thin; whorls rounded or distinctly shouldered, crossed by numerous laminated varices; spire elevated; canal long, straight or slightly curved, open; umbilicus closed; aperture ovate or rounded, outer lip simple or crenulated.

Animal as in the genus.

Operculum elongated, acute, with a nearly apical nucleus.

Dentition $1 + \frac{1}{6} + 1$, or $1 + \frac{1}{7} + 1$, the central cusps of the rhachidian tooth very long and pointed, the lateral cusps of uneven size; uncini long and prong-like, as in the genus.

Boreal in distribution.

Type. TROPHON CLATHRATUS, Linné.

Section TROPHONOPSIS[6] B. and D., 1882.

Shell differing from *Boreotrophon* in being more regularly fusiform, with more numerous varices.

Animal with a longer foot and tentacles, the eyes situated on swellings near the base.

Operculum as in *Boreotrophon*.

Dentition $1 + \frac{1}{6} + 1$, the cusps as in *Boreotrophon*.

Type. TROPHON MURICATUS, Mont.

Subgenus ASPELLA Mörch, 1877.

Shell fusiform, with a tendency toward lateral compression; whorls rounded, varices numerous; spire elevated; canal short, recurved, always open; aperture denticulate in the adult; nucleus small, at first obliquely and loosely wound, like a stranded rope, having a strong resemblance to a reversed nucleus.

Animal with a large foot, rounded behind, double edged in front, auriculated in the anterior corners; proboscis moderately long; tentacles small, close together, the eyes situated on their outer sides, half way between base and tip.

Operculum elongated, acute, with an apical nucleus.

Dentition $1 + \frac{1}{5} + 1$, resembling that of *Phyllonotus*.

Type. TROPHON ANCEPS, Lam.

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[6] It is with some doubt that I make this group a distinct section. It is altogether too nearly related to *Boreotrophon*. The shell, however, shows some differential characters, and it may be found convenient, at least, to retain the group as a section of *Boreotrophon*.

Genus OCINEBRA Leach, 1847.

Subgenus OCINEBRA (*sensu stricto*).

Shell fusiform, with from three to fourteen varices; varices round- l; umbilicus closed; spire elevated; canal moderate, open or closed, rned to the left; aperture round or ovate; outer lip dentate within.

Animal with a small, narrow foot, rounded in front, pointed be- nd; tentacles long, slender, tapering; eyes on long stalks exterior to d united with the tentacles for two thirds of their length; verge tuated on the right side, behind the tentacles.

Operculum like that of *Murex*, with the nucleus anterior, but not ical, and somewhat laterally situated.

Dentition $1 + \frac{1}{13} + 1$, the three central cusps of the rhachidian oth large, the others smaller; uncini long and pointed.

Type. OCINEBRA ERINACEUS, Linné.

Section CRASSILABRUM Jouss., 1880.

Shell broadly-ovate, with numerous varices; varices thick and rd-like, crossed by several equally thick spiral cords, giving the ell a latticed aspect; umbilicus closed; spire elevated; canal short, en, nearly straight.

Animal as in *Ocinebra* (*s. s.*)

Operculum and ***dentition***, unknown to me.

Type. OCINEBRA CRASSILABRUM, Gray.

Section OCINEBRINA Jouss., 1880.

Shell fusiform, with numerous rounded varices (ribs) crossed by trong spiral lines; spire elevated; canal short, open, straight; aperture vate, outer lip dentate within.

Animal with a small, narrow foot, rounded before, pointed behind; ntacles long, slender, tapering, microscopically ciliated, especially t the blunt tips; eyes and verge as in *Ocinebra* (*s. s.*)

Operculum of the purpuroid type.

Dentition $1 + \frac{1}{13} + 1$, the central cusp of the rhachidian tooth ery large, the lateral series with a large cusp at each end, and smaller nes in between; uncini long and prong-like.

Type. OCINEBRA ACICULATUS, Lam.

Subgenus FAVARTIA Jouss., 1880.

Shell fusiform, with numerous rounded varices, crossed by raised spiral lines; umbilicus closed, spire elevated, canal moderate, nearly closed; aperture rounded, outer lip slightly plicate within.

Animal as in *Ocinebra*.

Opeculum ovate or rounded, with apical nucleus.

Dentition unknown to me.

Type. OCINEBRA BREVICULA, Sowb.

Subgenus PTEROHYTIS[7] Conrad, 1862.

=*Cerastoma* Conrad, 1837.

Shell fusiform, ovate or pyriform, with three foliated or fin-lik varices, spire moderately elevated; no umbilicus; canal short, straigh closed; aperture oblong-ovate, outer lip dentate within, with produced tooth near its base.

Animal as in *Ocinebra*.

Operculum ovate, with lateral nucleus.

Dentition muricoid.

Type. OCINEBRA NUTTALLII, Conr.

Genus VITULARIA Swainson, 1840.

Shell oblong, with numerous, nearly obsolete varices; no distinc spiral sculpture; umbilicus open or closed; spire elevated; canal short straight, open; aperture a long oval, outer lip strongly dentate within

Animal as in *Ocinebra*.

Operculum oblong, smaller than the aperture, rather thin, nucleu lateral.

Dentition unknown to me.

Type. VITULARIA SALEBROSA, King.

Genus MURICIDEA (Swains.) Mörch, 1840.

Shell fusiform, with numerous spiny varices or rounded ril umbilicus closed; spire elevated; canal moderate, open, curve aperture oblong or rounded, outer lip generally plicate within.

Animal as in *Murex*.

Operculum resembling that of *Fusus*, ovate, with apical nucleus.

Dentition unknown to me.

Type. MURICIDEA HEXAGONA, Lam.

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[7] The name *Cerastoma* was used by Labrille, in 1802, for an apparently valid genu *Lepidoptera*. The only course to be adopted is to accept Conrad's name proposed in 18 a group of fossil Murices, closely related to *Cerastoma*.

Genus UROSALPINX Stimpson, 1865.

Shell short-fusiform, with numerous longitudinal ribs, crossed by sed spiral lines; umbilicus closed; spire elevated; canal short, open, ved; aperture oval, outer lip dentate or lirate within.

Animal small, foot scarcely large enough to fill the aperture; head rcely protruded; tentacles nearly united at their base, tapering a mere filament; eyes situated at upper third of the tentacle, on the tside. Verge as in *Murex*.

Operculum externally like *Murex;* semi-cordate, with the nucleus at outer edge, a trifle below the middle; internally showing gyratory rs as in *Purpura*.

Dentition $1 + \frac{1}{6} + 1$, the rhachidian tooth with numerous minute nticles between the principal cusps; uncini long and prong-like.

Type. UROSALPINX CINEREUS, Say.

Genus TYPHIS Montfort, 1810.

Shell pyriform or oblong, with four varices;[8] umbilicus scarcely ible; whorls shouldered, with projecting hollow tubes continuous th or between the varices; spire depressed; canal moderate, closed, arly straight, aperture sub-orbicular.

Animal resembling *Murex*. The ascending tube (this is at first not ollow cylinder, but a fold of the mantle) is occupied by an exten- n of the mantle margin. Foot long and narrow; tentacles thick d broad; eyes situated at their base.

Operculum ovate, with sub-apical nucleus, like that of *Murex*.

Dentition unknown to me.

Type. TYPHIS TETRAPTERUS, Bronn.

Section I. TYPHIS (Typical).

Ascending tube placed between the varices.

Animal, operculum and *dentition* as in the genus.

Type. TYPHIS TETRAPTERUS, Bronn.

Section II. TRUBATSA Dall, 1889.

Ascending tube continuous with varices.

Animal, operculum and *dentition* as in the genus.

Type. TYPHIS LONGICORNIS, Dall.

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[8] Notwithstanding the fact that this genus has been described as three-varicose by almost ry monographer, I maintain, and so will all who will examine *carefully* a specimen, that four-varicose. I may add that I have never seen a specimen with three varices, either l or recent.

SUBFAMILY II. PURPURINÆ.

The principal characters of this group are, the short, merely notched canal, the comparatively smooth whorls (in some species nodulous, however), the broad and fattened columella, operculum with lateral nucleus, and rhachidian tooth of the radula with numerous dentacles. The same rule applies to this group, as that spoken of under *Muricidæ*.

Genus PURPURA Brug., 1789.

Shell oblong-oval, whorls smooth or nodulous; last whorl very large; spire generally short; aperture ovate, very large; canal short oblique, often a mere notch; columella flattened; outer lip generally simple, sometimes lirate.

Animal with a large foot, truncate in front, pointed behind (the foot is not as large, comparatively, as in *Murex*); head very distinct tentacles sometimes placed on stalks near the base; siphon generally short; verge as in *Murex*.

Operculum ovate or elongate, with lateral nucleus, showing on the interior gyratory scars.

Dentition $1 + \frac{1}{5} + 1$ to $1 + \frac{1}{9} + 1$; the three central cusps very large, the lateral cusps very small; uncini long and fang-like.

Type. PURPURA PERSICA, Linné.

Subgenus PURPURA[9] (Typical).

Shell oblong oval, whorls smooth; last whorl very large, occupying three-quarters of the length of the shell; spire short; aperture ovate, flattened; outer lip lirate within.

Animal and *operculum* as in the genus.

Dentition $1 + \frac{1}{5} + 1$, the middle cusp of the rhachidian tooth very long, the middle side cusps small, and the lateral cusps larger uncini long and pointed.

Type. PURPURA PERSICA, Linné.

Subgenus PURPURELLA Dall, 1872.

Shell oblong-oval, whorls covered by rounded nodules; last who very large; canal a mere notch, spire depressed; aperture ovate, out lip dentate within; columella flattened, with one or two distinct spi ridges upon its center, extending from columella to apex.

Animal and *operculum* as in the genus.

Dentition as in *Purpura*.

Type. PURPURA COLUMELLARIS, Lam.

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[9] Hutton (P. N. Z. Inst., vol XVI, 1883) has diagnosed a new genus (*Lepsia*) for *Pur haustrum*, Martyn, but I can see no really distinctive characters by which to separate it f *Purpura* (typical).

Subgenus TRIBULUS Klein, 1753.

Shell oval, whorls nodulous; last whorl very large, ventricose; erture very wide, ovate; inner lip excavated, corrugated at the fore-rt; outer lip dentate within; canal very short; spire depressed.

Animal and *operculum* as in the genus.

Dentition $1 + \frac{1}{11} + 1$, the three central cusps of the rhachidian oth very large and prong-like, with a small denticle between, the ree lateral denticles very small; uncini long and fang-like.

Type. PURPURA PLANOSPIRA, Lam.

Subgenus THALESSA H. and A. Adams, 1853.

Shell ovate or pyriform; whorls smooth or nodulous; angulated at e upper part; spire elevated; aperture occupying half the length of e shell, ovate; columella rounded, tubercular in front; canal a mere otch; outer lip nodulous within.

Animal resembling that of *Purpura*, but foot smaller and longer.

Operculum as in *Purpura*.

Dentition $1 + \frac{1}{9} + 1$, the central cusp of the rhachidian tooth very rge, the next two large and bifid; lateral cusps very small; uncini ng and pointed.

Type. PURPURA HIPPOCASTANEUM, Linné.

Subgenus STRAMONITA Schum., 1817.

Shell ovate; whorls simple or nodulous; spire elevated; aperture oderate, produced anteriorly; columella rounded, simple in front; nal short; outer lip lirate within.

Animal and *operculum* as in *Purpura*.

Dentition $1 + \frac{1}{9} + 1$, $1 + \frac{1}{11} + 1$, the cusps of the rhachidian oth as in *Thalessa*. Uncini as in the preceding groups.

Type. PURPURA HÆMASTOMA, Linné.

Subgenus TROCHIA Swains., 1840.

Shell ovate; whorls crossed by numerous raised spiral lines or s, and separated by deep grooves; spire usually elevated; aperture oderate; canal short; columella rounded, slightly excavated near e base; outer lip thickened, convex, lirate within.

Animal and *operculum* as in the genus.

Dentition as in *Thalessa*.

Type. PURPURA CINGULATA, Linné.

Subgenus POLYTROPA Swains., 1840.

Shell a long oval; whorls foliated or tuberculose; spire acuminate; aperture rounded, narrowed at the fore part; canal short, oblique; columella arcuate; outer lip smooth or lirate within.

Animal with a small foot; other characters as in the genus.

Operculum as in *Purpura*.

Dentition $1 + \frac{1}{5} + 1$, the cusps of the rhachidian tooth large and of equal size; uncini as in *Purpura*.

Type. PURPURA LAPILLUS. Linné.

Subgenus CRONIA H. and A. Adams, 1853.

Shell long-ovate; whorls crossed by raised spiral lines; spir acuminate; aperture long-ovate, moderate; canal very short; inne lip with a callous at the upper part; columella straight, simple ante riorly; outer lip dentate or lirate within.

Animal and *operculum* as in the genus.

Dentition unknown to me.

Type. PURPURA AMYGDALA, Kiener.

Subgenus AGNEWIA[10] Tenison-Woods, 1877.

Shell long-ovate, inclining to fusiform; whorls ribbed or nod lous; spire acuminate; aperture small, rounded; canal a mere notc columella arcuate, smooth; outer lip lirate within.

Animal and *operculum* as in *Purpura*.

Dentition unknown to me.

Type. PURPURA TYPICA, Dunker.

Genus RAPANA Schum., 1817.

Shell ventricose, axis perforated to the apex; whorls angulated the shoulder; spire depressed; aperture oval, narrowed anteriorl canal short, open, slightly recurved; inner lip reflected, free anterio ly; umbilicus wide, corrugated; outer lip smooth or very slightly lira within.

Animal and *operculum* resembling that of *Purpura*.

Dentition $1 + \frac{1}{13} + 1$, the central cusp of the rhachidian toot very large, the two on either side large, and strengthened by seven small denticles; lateral cusps small; uncini long and fang-shaped.

Type. RAPANA BULBOSA, Solander.

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[10] Dunker characterized the genus *Adamsia* in 1856; but this name being preoccupied by Forbes in *Anthozoa*, Rev. E. Tenison-Woods. in 1877, changed the name to *Agnewia*. T genus has been placed in *Cominella* and *Urosalpinx*, but its proper place is, I believe, in *P pura*.

Genus CYMIA[11] Mörch, 1877.

Shell short fusiform; whorls strongly angulated in the middle; re elevated; aperture ovate; canal short, open: columella with a ge plait running clear up to the apex; inner lip reflected: umbili- s open, corrugated; outer lip lirate within.

Animal and ***operculum*** resembling ***Purpura.***

Dentition $1 + \frac{1}{1} + 1$, the central cusp of the rhachidian tooth very ge, the next two smaller and bifid, and the lateral cusps very all; uncini long and fang-shaped.

Type. CYMIA TECTUM, Wood.

Genus JOPAS H. and A. Adams, 1853.

Shell ovate; whorls rugose, last large; spire acuminate; aperture derate: emarginate and channeled in front; columella covered th a thin enamel; with a prominent plait-like callosity near the an- ior canal; canal short, open; outer lip sinuous, crenate within.

Animal resembling that of ***Purpura;*** the foot is long and narrow, ncate before, rounded behind; head distinct: tentacles moderate, pering, the eyes situated about a third of the distance from the tside; verge as in ***Purpura.***

Operculum purpuroid.

Dentition $1 + \frac{1}{1} + 1$, the central cusp of the rhachidian tooth ry large, lateral cusps smaller; uncini long and pointed.

Type. JOPAS SERTUM, Brug.

Genus VEXILLA Swains., 1840.

Shell long-ovate; whorls smooth; spire moderate; aperture very ng and narrow; inner lip flattened and depressed; outer lip thick- ed (in the adult) and dentate within: canal very short.

Animal resembling that of ***Purpura;*** foot long and narrow, trun- te before, rounded behind; tentacles and eyes as in ***Jopas.***

Operculum purpuroid.

Dentition unknown to me.

Type. VEXILLA VEXILLUM, Chemn.

Genus PINAXIA H. and A. Adams, 1850.

Shell conical; spire short, acute; whorls smooth, tuberculose on e shoulder; aperture oval-oblong, emarginate anteriorly; inner lip ttened, with several transverse plaits in the middle: outer lip acute, ooved internally; canal very short.

Animal unknown.

Operculum purpuroid.

Dentition unknown.

Type. PINAXIA CORONATA, A. Adams.

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[11] The name *Cuma* (Humph, 1797) Swains., 1840, is generally used for this group, but that me is used for a group of Crustacea.

Genus ACANTHINA[12] Fischer, 1807.

Shell ovate, last whorl large, rough or smooth; spire moderate o very short; aperture ovate or semilunar; inner lip wide and flattened outer lip thick or thin, crenated, with a prominent tooth at the for part; canal very short, open.

Animal with a short, narrow foot, rounded at both ends; hea distinct; tentacles long and tapering, widely separated at their bas eyes placed upon swellings midway between base and tip; siphon medium size; verge as in *Purpura*.

Operculum purpuroid, triangular.

Dentition 1 — 1 — $\frac{1}{0}$ — 1 — 1, the central cusp of the rhachidian toot triangular; those next triangular and tridentate; the lateral cus ovate, and smaller; uncini as in *Purpura*.

Type. ACANTHINA IMBRICATA, Lam.

Subgenus CHORUS[13] Gray, 1847.

Shell resembling *Acanthina*, but with longer spire and canal; th shell is smooth, and the tooth on the outer lip very large. It is separated from *Acanthina* chiefly by its pyriform shell.

Animal, operculum and *dentition* as in *Acanthina*.

Type. ACANTHINA GIGANTEUM, Lesson.

Genus PENTADACTYLUS[14] Klein, 1753.

Shell ovate, very solid; varices nodulous or scaly; spire ve short, aperture linear, narrow, contracted by callous projections; inner lip tuberculately wrinkled; outer lip with plait-like teeth, withi digitate, canal short, oblique, open, emarginate in front.

Animal with a rather broad foot; head distinct; tentacles lon thick, separated at base, eyes situated on the outside midway betwee base and tip, siphon of medium size; verge as in *Purpura*.

Operculum purpuroid.

Dentition [illegible] — 1 — [illegible] — 1, the central cusp of the [illegible] large, triangular, the cusps immediately on right and [illegible] the lateral cusps small and placed like the teeth [illegible] [illegible] long and large [illegible]

Type. PENTADACTYLUS [illegible], Lam.

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[12] [illegible] Lam. [illegible]

[13] [illegible] *Purpura*, [illegible]

[14] [illegible] *Purpura*, Lam. [illegible] represent the small forms [illegible]

Subgenus Morula Schum., 1817.

ell with a longer spire, smaller size and more fusiform than in *actylus*. The teeth within the outer lip single, not grouped.
imal resembling *Pentadactylus*. The eyes are sometimes on prominences and the foot is narrower.
erculum as in *Pentadactylus.*
ntition 1 + $\frac{1}{9}$ + 1, the central cusp of the rhachidian tooth rge, those on either side smaller and bifid, the laterals very uncini long and pointed.

Type. Pentadactylus morus, Lam.

Genus Concholepas Lam., 1801.

ell ovate, last whorl very large, expanded; spire very short, ly inclined toward the left side; aperture very wide, slightly led anteriorly; inner lip flattened; outer lip with two small front.
imal with a very large foot; head and tentacles as in *Purpura;* aced midway between base and tip of tentacles; siphon moderge as in *Purpura.*
erculum purpuroid, but entirely too small to fill the aperture.
ntition 1 + $\frac{1}{9}$ + 1, the central cusp of the rhachidian tooth id triangular, those on each side large and bifid; lateral cusps all; uncini long and fang-like.

Type. Concholepas peruvianus Lam.

Subfamily III. CORALLIOPHILINÆ.

principal characters of this group are the short canal, thin, cases scabrous shell, and its habit of living in coral; the ***m,*** when present, is ovate with sub apical nucleus; verge , swollen, club shaped; radula wanting (?).

Genus Rhizochilus, Steen., 1850.

ll, when young, free, resembling *Rapana;* when adult, someith more or less irregular solid shelly extensions of the outer r lips, which clasp the axis of coral (*Antipathes);* surface of gh and scabrous; spire elevated; aperture long-oval; canal ong, open.
mal resembling *Latiaxis.*
erculum none (?).
tition not observed.

Type. Rhizochilus antipathicus, Steen.

Genus LATIAXIS[15] Swainson, 1840.

Shell variable, or pyriform, rough and scabrous; spire very short or much elevated; aperture ovate; canal very short, open; inner lip reflected, smooth; outer lip crenate internally; umbilicus generally open and very wide and deep.

Animal with an oval, moderate foot; head and tentacles distinct, the latter rapidly tapering to a point; eyes sessile, midway between base and tip; verge (?); siphon short.

Operculum resembling *Purpura*, with the necleus lateral.

Dentition not observed.

Type. LATIAXIS NERITOIDEA, Lam.

Subgenus CORALLIOBIA, H. and A. Adams, 1853.

Shell differing from *Latiaxis* in being broadly ovate, flattened, and with the outer lip much expanded, concealing the spire.

Animal as in *Latiaxis*.

Operculum wanting (?).

Dentition not observed.

Type. LATIAXIS FIMBRIATA, A. Ad.

Genus LEPTOCONCHUS Rüppel, 1834.

Shell ovate, thin, last whorl very large; spire very short; aperture semi-lunar; inner lip arcuate, covered with a light callous; outer lip thin, somewhat expanded; no anterior canal.

Animal with a greatly thickened and fleshy mantle margin; tentacles small, broad, and united at their bases; eyes small and black, on the outer side of the tentacles, near their tips; foot small, short, obtuse and rounded behind, with a thin, expanded disc-like lobe in front; siphon obsolete; verge straight, acuminate, swollen, club-shaped at the extremity, placed on the right side of the body.

Operculum wanting.

Dentition not observed.

Type. LEPTOCONCHUS CUMINGII, Desh.

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[15] There has been much confusion over this generic name. I have recently examined eral specimens of *Latiaxis mawæ* (Gray), and am firmly convinced that it is but an ab mally loosely coiled specimen of *Coralliophila*. *Pseudomurex*, also, is a synonym; the op *culum* is identical, and the shell characters fade into one another. The synonomy, then, stand as follows:

Latiaxis Swainson, Man., p. 206, 1840.
Coralliophila, H. & A. Adams, Gen. Rec. Moll., I, p. 135; 1853.
Pseudomurex Monterosato, Conch, Medit., p. 48; 1872.

Genus MAGILUS[16] Montfort, 1810.

Shell when young as in *Leptoconchus,* when adult forming a long e by the shelly expansion of the outer and inner lips.

Animal as in *Leptoconchus.*

Operculum oval, concentrically laminated, with lateral nucleus.

Dentition not observed.

Type. MAGILUS ANTIQUUS, Lam.

Genus RAPA Klein, 1753.

Shell thin, grobosely pyriform; umbilicus deep, perforating the is to the apex, the umbilicus partly concealed by the reflected inner ; spire very short, flat; aperture oblong, produced anteriorly into wide, sub-recurved canal; inner lip reflected; outer lip thin, crenate.

Animal resembling that of *Leptoconchus.*

Operculum purpuroid, thin and translucent.

Dentition not observed.

Type. RAPA PAPYRACEA, Lam.

GENERA FORMERLY INCLUDED IN THE MURICIDÆ, BUT NOW REFERRED OTHER FAMILIES.

Genus PSEUDOLIVA, Swainson. 1840.

=Buccinidæ.

Genus MELAPIUM, H. and A. Adams, 1853.

=Buccinidæ.

Genus MAGILINA, Vélain.

=Vermetus.

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[16] LEPTOCONCHUS is separated from *Magilus* on account of the absence of the *operculum* in he former, and in the possession of a long tube in the latter. Should these characters prove table, after the examination of a large amount of fresh material, then they should most cerainly be separated. Many of the species placed in *Leptoconchus* are strongly suggestive of the young of *Magilus* before the tube is formed.

rvous System (Pl. IV, figs. N, P; pl. V, figs. A, B).

he nervous system is made up of a nervous collar (ganglia) nding the œsophagus, just posterior to the radula sac, series of nerve cords. The cerebral ganglia lie above the agus and all the other ganglia lie below it.

he *cerebral ganglia* (CG) are situated above or a little to de of the œsophagus and are joined to each other, to the ganglia and to the pleural ganglia by short, thick comres. The right cerebral ganglion sends a nerve to the generative organ which divides before reaching that organ, ranch going to the penis (PNE) and the other, which subdivides, innervating the penis sac (PSN). The cerebal ia also send nerves to the tentacles (NT), optic nerves to (ON), nerves to the front of the head (FN), labial nerves region of the mouth (LN), and a pair of nerves to the l sac. These latter or cerebral commissures (CC) enlarge e buccal sac to form the buccal (BG) or stomato-gastric a. These ganglia send out a number of small nerves innervate the buccal sac and the manducatory organs V, figs. N, P). Branches are also sent to the salivary s.

he *pedal ganglia* (PG) are very large, lie directly beneath sophagus, and are connected with the cerebral and pleural ia by short, thick commissures. These ganglia send off ts of nerves of three each, the first, inferior and superior al and columellar nerves (IC, SC, CN) to the posterior and the second, superior, inferior and central pedal nerves , SP) to the anterior part of the foot. There are several short, minute nerves whose functions are unknown to the . The otocysts (OT) are placed in the posterior part of ganglia, and are connected with some of the other ganglia e nerves.

he *pleural ganglia* (LG) lie below the œsophagus, and are cted by short, thick commissures with the pedal, cerebral isceral ganglia. They apparently send off no nerve cords.

he *visceral ganglia* (VG) lie behind, a little above the l ganglia, and are connected with the latter and the inal ganglia by short commissures. The right ganglion off a long nerve (V′ right pallial nerve) which innervates nale genital orifice, a portion of the respiratory cavity and the right posterior part of the mouth. Near the end of this nerve an enlargement forms the olfactory organ or osphradium (os . A shorter nerve (v, anterior pallial), leaves this ganglion near the one spoken of, and shortly joins a similar one from the abdominal ganglion, the combined nerve passing to the vagina, the anterior part of the mantle and the respiratory cavity.

The left ganglion sends off a single long nerve which innervates the mantle along its sides (L M).

The *abdominal ganglion* (A G), which is really two ganglia fused together, lies behind and somewhat below the visceral ganglia, is connected with the latter by two short, thick commissures, and sends off four nerves. One of these has already been described under the right visceral ganglion. The central nerve (S I) is the longest and innervates the pericardium, aorta, part of the genitalia, the rectum, kidney and respiratory cavity. A somewhat shorter nerve on the right of this (A) furnishes nerve force to the posterior part of the aorta and a part of the genitalia. To the left of the central nerve a small nerve supplies the anterior part of the mantle. The nerves of the abdominal and visceral ganglia also innervate different portions of the digestive system.

In a living specimen the ganglia are of a very bright orange color, but in alcoholic specimens they are yellowish or yellowish white. The eyes are as usual in androgynous Pulmonata. The sclerotic membrane, choroid, cornea, etc., are well developed, and the optic nerve is very large.

In working out the foregoing, Lacaze Duthiers' article in Archiv. de Zool. Exp., has been followed as a guide. The nervous system of the present species may be said to be almost identical with that of *Limnæa pereger* described and figured by Lacaze Duthiers (pl. 17, fig. 2). Spengel's figure of *L. stagnalis* is also the same (taf. xvii, fig. 11), excepting that the nerves to the penis and vagina are not shown. Moquin-Tandon's figures are different, his *Limnæa palustris* (pl. 34, fig. 27) showing a fused condition of the abdominal and visceral ganglia. In his figure of *L. auricularia* the pleural and visceral ganglia appear to be fused and the nerves are insufficiently shown. No figures, excepting Lacaze Duthiers', show the peculiar innervation of the male and female genitalia.

culatory System (Pl VI; pl. IV, figs. F, G; pl. III, figs. H, J).

The heart is on the left side of the animal, at the apex of respiratory cavity, and lies laterally between the œsophagus l the rectum, and not far from the stomach; it is also between anterior portion of the liver and is bounded on the right by kidney. The ventricle and auricle lie in a large oblong ricardium (PE, A, V); a large aorta which leaves the ventricle n divides into two main branches the *aorta cephalica*, which pplies the œsophagus, stomach, intestines, etc., and the *aorta ceralis*, which supplies the liver and hermaphrodite reproduct- organs; this branch splits into two main branches (RV, LV), e going to the liver and the other to the sexual organs.

The *aorta cephalica* extends from the ventricle to a point out the middle of the left crop, where it splits into four main anches, two anterior and two posterior, one pair passing down ch side of the œsophagus and the other down each side of the testine and rectum and finally uniting with the branchial exus (pl. vi, LVO, ILV, G).. From the four main branches out the stomach, several large branches are given off, which turn imbranch, forming an arborescent plexus over the mach, crop and gizzard. The lateral vessels of the œsophas and intestine also form plexuses over both of the latter ans, and two large branches are given off for the salivary nds (S). A complicated plexus is formed over the buccal sac , and here the lateral vessels send branches to the eyes, tacles, penis and two large branches to the foot (E, T, F, P). e branch to the penis divides, forming two main branches, ich imbranch many times, forming a plexus over that organ.

One branch of the *aorta visceralis* (RV) supplies the herma. roditic reproductive organs and divides into four main anches on those organs, one branch supplying the ovotestis V), another the oviduct and vagina (VA), another the pros- e (PR), and still another the receptaculum seminis. All of se branches subdivide many times and form plexuses over se organs.

The second branch of the *aorta visceralis* is very long and plies the liver (LV). In this organ there are three main nches, each with several smaller branches, which in turn ranch to form a dense network or plexus (LI).

The mantle is supplied with a plexus of fine bloodvessels which collect the blood into two large veins, and several smaller ones (M) and which finally unite with the branchial artery (BA). There are no veinous capillaries present, the blood flowing freely about the cœlomic cavity and being collected in the two veins, as already explained.

The writer has been unable to find any reference to the two lateral vessels of the œsophagus and intestine in any work, most figures showing but one vessel. These two vessels were found in all the specimens examined in the position shown in the figures. A cross section of the intestine shows these branches to be true lateral vessels, placed very much like the dorsal and ventral vessels in the earthworm (pl. iii, H). Dorsal and ventral branches (BLV, pl. iii.) are given off which imbranch to a most wonderful degree, forming a typical plexus (pl. iii, J; see also pl. iv, F, G). The arteries and veins were almost black in freshly killed specimens, but the blood itself appeared uncolored.

The circulation does not differ materially from that of any of the Pulmonata, and is similar to the descriptions and figures in Keferstein and Leidy, with the exception of the two lateral vessels of the œsophagus and intestine.

Respiratory System (Pl. III, fig. I; pl. VI).

The respiratory cavity or lung occupies nearly half of the last whorl, when dilated (pl. IV, L). It is longer than wide, and is supplied with a network of blood vessels, forming small fossets (pl. III, fig. I). These connect with the branchial artery, which conducts the æriated blood into the auricle and from this organ to the ventricle. The respiratory cavity is situated on the right side of the body and is closed by a lobe of the mantle, which forms a sort of siphon.

This species does not seem to require oxygen frequently, if one can judge by its actions in captivity. Several specimens confined in a large glass of water visited the surface about three times daily.

Renal System (Pl. VI, K, U).

The kidney lies on the right side of the pericardium, and is a long, cylindrical organ with hard, muscular walls. A ureter (U) leaves the posterior end of the kidney and has its exit not far from the anus. The kidney is covered with a plexus of blood ssels, which open into it in several places, thus allowing e urinary products to mix with the blood. The structure the kidney is as usual in the Pulmonata.

luscular System (Pl. III, figs. D, E; pl. IV, figs. O, P, Q).

Besides the columella muscle and the muscular tissue formg the walls of the different organs, there are a number of free uscles of great importance. These are the retractors of the xual organs and also of the tentacles and buccal organs. The ccal retractors (pl. IV, fig. P, Q) are two in number and are tached to the columella muscle. The retractors of the tentacles ne for each) are rather wide bands, and are also attached steriorly to the columella muscle (pl. III, O).

The retractors of the genital system are nearly all attached the diaphragm or floor of the lung. The penis retractor is a ng, ribbon-like band of muscle with one end inserted in the se of the penis and the proximal end inserted in the columella scle. The penis retractor has a short branch, which leaves about the middle, and is inserted in the upper part of the nis sac by means of a number of small muscles produced by e splitting up of the main muscle. The penis sac is supplied th three protractors, the distal insertions (on the penis sac) litting once, and these in turn again, making four separate sertions for each muscle. Two muscles are inserted near the wer part, and one near the middle of the penis sac. (Pl. III, l, PSM).

The vagina is supplied with two retractor muscles, similar form to those of the penis sac, the distal insertions (on the gina) being three in number caused by splitting as described r the penis sac, and inserted, one on the lower part and one ar the center (pl. III, D, VM).

The retractors of the foot are attached to the columella scle, as in most spiral shells.

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EXPLANATION OF PLATE I.

A. *Limnæa emarginata* SAY, from Owasco Lake, Cayuga Co., N. Y., showing variation from the long to the short-spired form. (Dr. H. N. Lyon.)

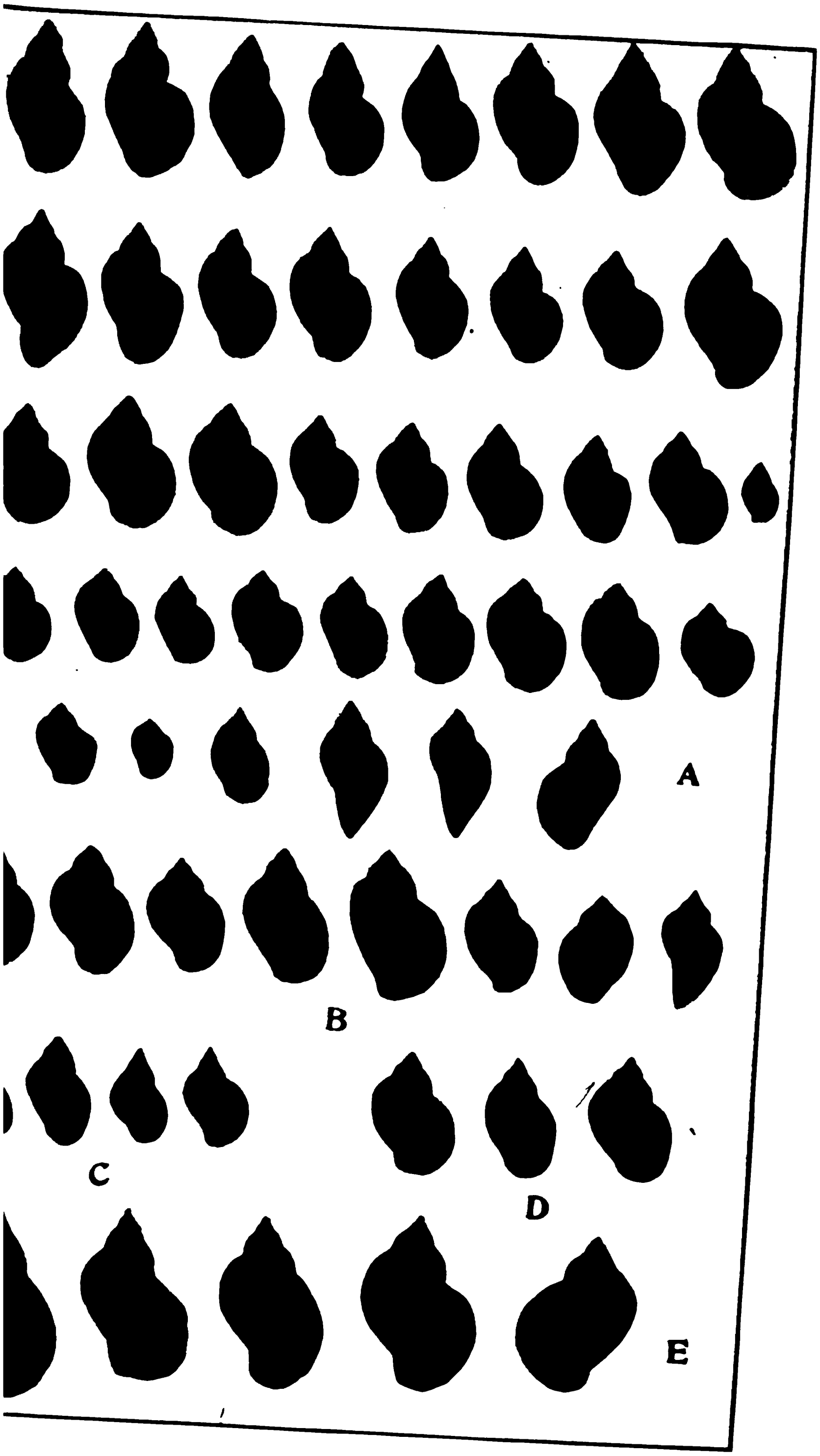
B. The same from Aroostook River. Caribou, Aroostook Co., Maine, (O. F. Nylander.)

C. The same from Pigeon Lake, Ontario Province, Canada. (Geo. H. Clapp.)

D. The same from First of Four Lakes, Madison, Wisconsin. (P. P. Carpenter.)

E. The same from Owasco River. Cayuga Co., N. Y. (Dr. H. N. Lyon.)

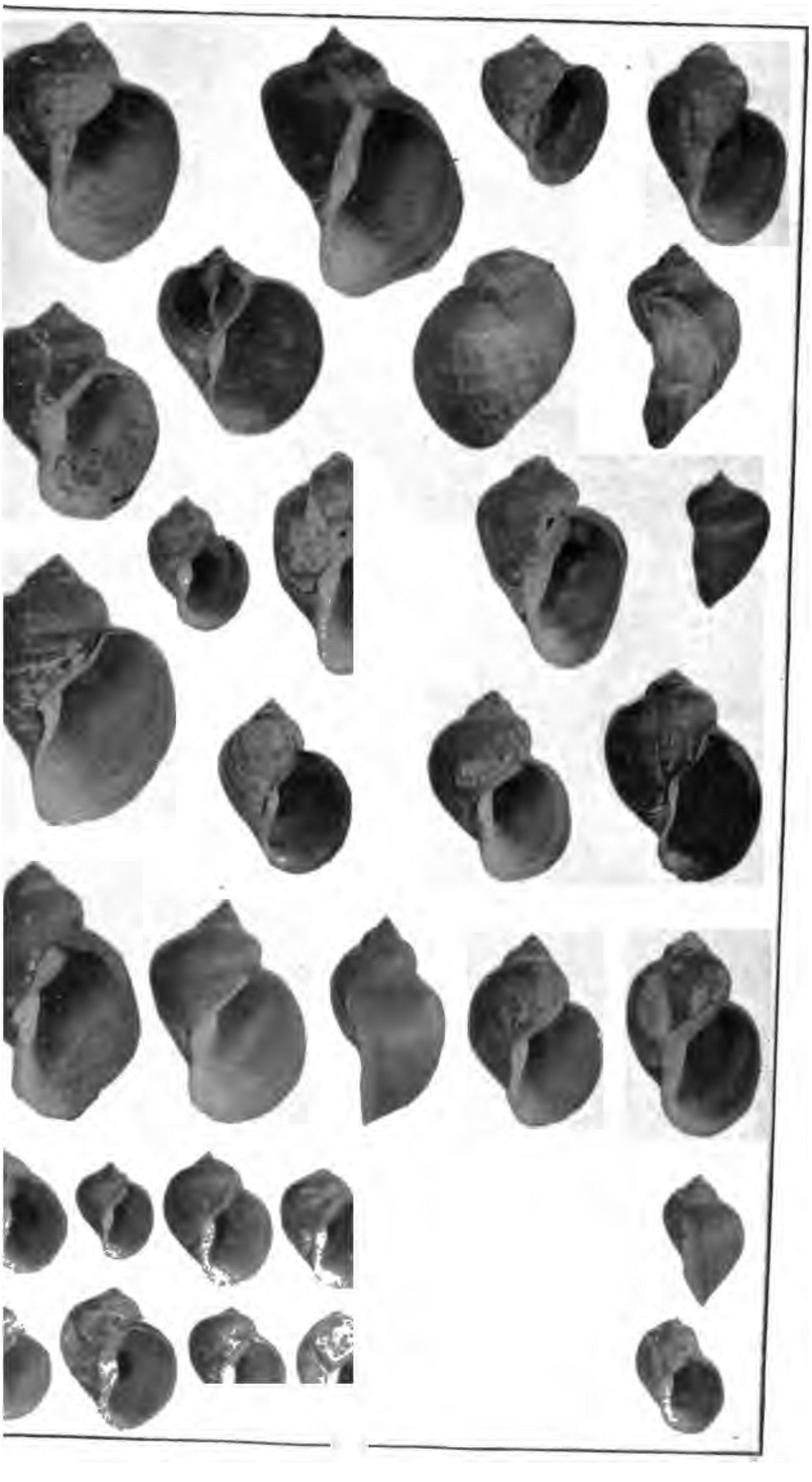
PLATE I.



EXPLANATION OF PLATE II.

Showing variation of shells of *Limnæa emarginata* SAY, variety *mighels*, Binney, from the form with elevated spire and narrow aperture to that with a short spire and wide, spreading aperture. All from Cross Lake, Aroostook Co., Maine. (Olof O. Nylander.)

PLATE II.



EXPLANATION OF PLATE III.

A. B. C. Animal of *Limnæa emarginata* SAY, var. ***mighels***, Binney. A, from above; B, from below; C, from the right side, showing extended velum.

D. Genitalia (principally female).

A, atrium or vestibule of vagina; AL, albuminiparous gland; O, ovotestis; OD, ovisperm duct; PD, duct of prostate gland; PR, prostate; S, spermatheca or receptaculum seminis; SD, duct of spermatheca; V, vagina; VM, retractor muscles of vagina; U, uterus.

E. Male organs.

CG, cerebral ganglion; CM, columella muscle; F, flagellum; P, penis; PG, pleural ganglion; PN, nerve to penis; PS, penis sac; PSM, penis sac protractor muscles; PSN, penis sac nerve; RM, retractor muscle of penis; VD, vas deferens; G, visceral ganglion; VN, nerve to vagina.

F. Portion of ovotestis, showing blood vessels (x 519).

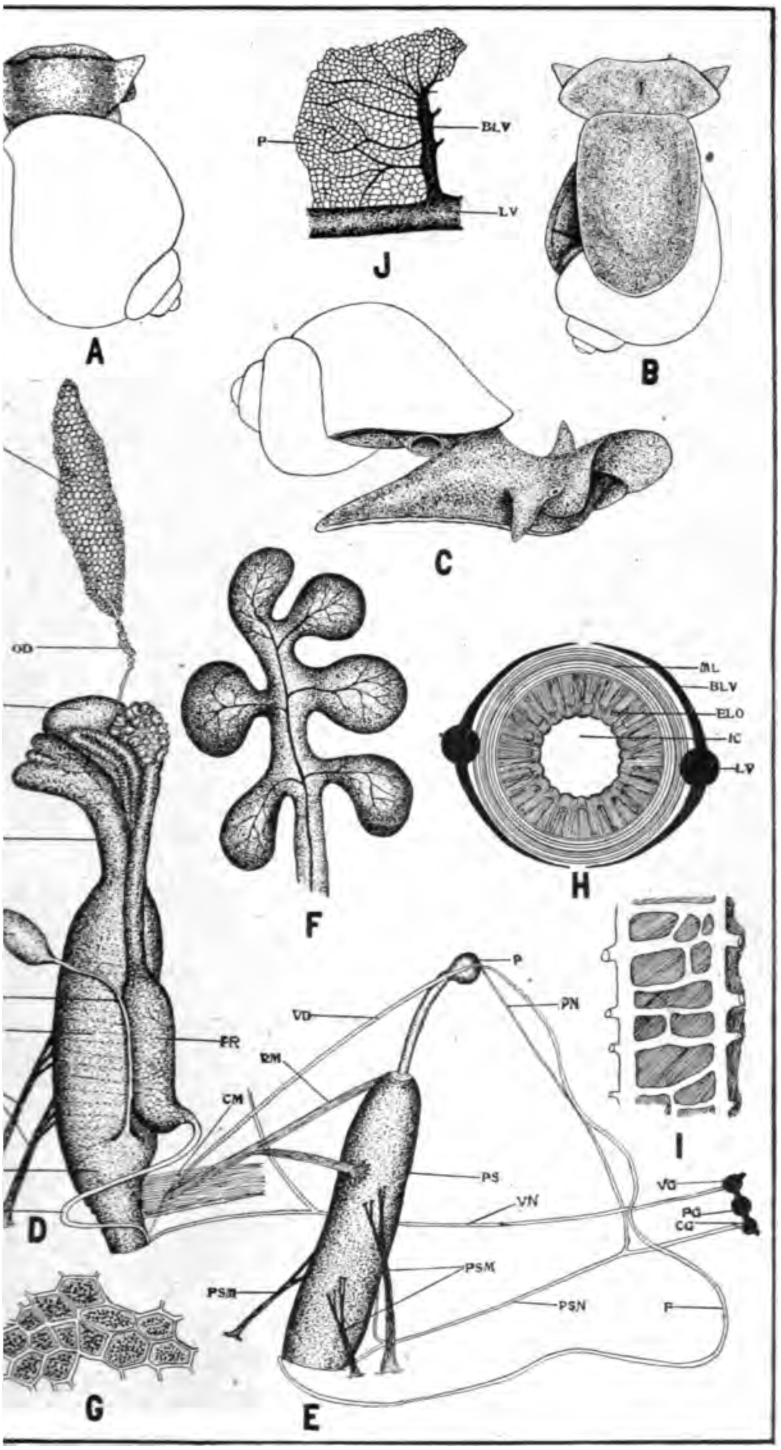
G. Cells from the albuminiparous gland (x 519).

H. Diagramatic section of intestine; BLV, branch of lateral blood vessel; ELO, epithelial layer of œsophagus; IC, intestinal cavity: LV, lateral blood vessel; ML, muscular layer of œsophagus.

I. Portion of lung, showing two main vessels and several connective vessels (x 519).

J. Portion of lateral blood vessel with one branch with its connective plexus (x 519).

PLATE III



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EXPLANATION OF PLATE IV.

A. Radula; C, central tooth; 1, first lateral; 2, second lateral; 10, tenth lateral; 16, transition tooth; 17, 20, 21, 30, marginal teeth; 32, 34, extreme marginals.

B. Radula of another specimen; 11, eleventh lateral; 14, transition tooth; 15, first marginal.

C. Digestive system, seen from above, the intestine and liver turned to the right. The whole system is dissected and spread out (see K); A, anus; BS, buccal sac; BV, blood vessel of liver; G, gizzard; I, intestine; L, liver; LV, lateral blood vessel; M, mouth; O, œsophagus; P, pyloris; R, rectum; S, crop; SG, salivary gland; SD, duct of salivary gland.

D. Stomach, crop and gizzard from below; lettering same as C.

E. Stomach, crop and gizzard from the left side; lettering as in C.

F. Portion of intestine showing lateral blood vessel, one on each side (x 100).

G. Portion of intestine showing lateral vessel and three branches (x 200).

H. Cells from the liver (x 519).

I. Cœlomic epithelial cells of mantle (x 519).

J. Connective muscle cells from mantle (x 519).

K. Limnæa mighelsi partly dissected to show natural position of intestine. L, liver; I, intestine; → indicates the natural course of the intestine from mouth to anus.

L. Portion of salivary gland near duct, showing numerous blood vessels (x 519).

M. Jaw.

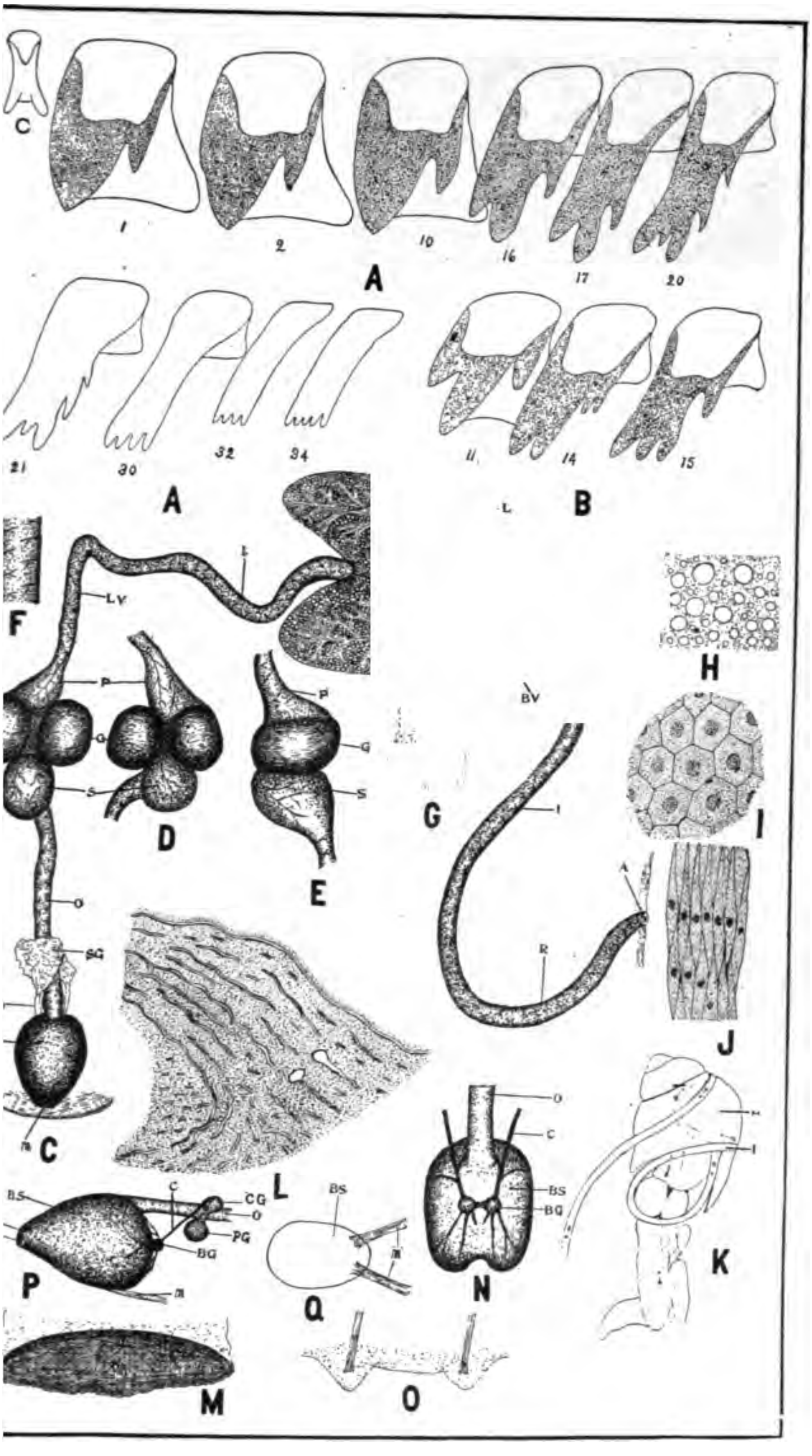
N. Buccal sac, viewed from the posterior end, the œsophagus turned forward; BG, buccal ganglion of left side; BS, buccal sac; C, connective nerve between buccal ganglion and cerebral ganglion; O, œsophagus.

O. Tentacles, showing retractor muscles.

P. Buccal sac, viewed from the left side. BG, BS, C and O as in fig. N; CG, cerebral ganglion; J, jaw; M, retractor muscle; MO, mouth; PG, pedal ganglion.

Q. Buccal sac viewed from below and turned forward; lettering as in P.

PLATE IV.



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EXPLANATION OF PLATE V.

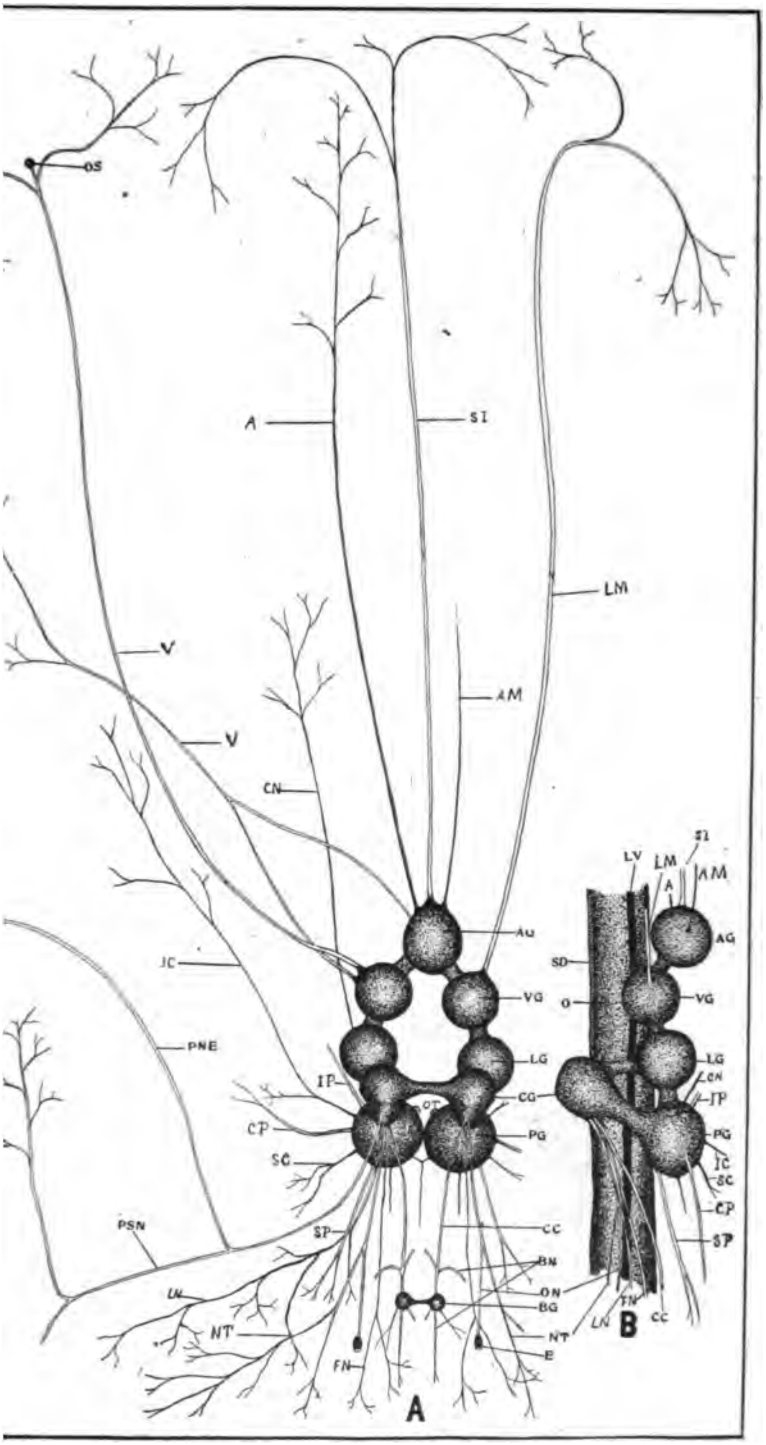
A. Nervous system viewed from above.

B. Same viewed from the left side.

A. Aortic nerve. AG, abdominal ganglion; AM, anterior mantle nerve; BG, buccal ganglion; BN, buccal nerves; CC, cerebro-buccal connective; CG, cerebral ganglion; CN, columella nerve; CP, central pedal nerve; E, eye; FN, frontal nerve; IP, inferior pedal nerve; IC, inferior cervical nerve; LG, pleural ganglion; LN, labial nerve; LV, lateral bloodvessel; LM, lateral mantle nerve; NT, tentacular nerve; O, œsophagus; ON, optic nerve; OS, osphradium; OT, otocysts; PG, pedal ganglion; PNE, penis nerve; PSN, nerve to penis sac; SD, duct of salivary gland; SC, superior cervical nerve; SP, superior pedal nerve; SI, genital nerve; VG, visceral ganglion; V, anterior pallial nerve; V, right pallial nerve.

The left visceral ganglion is a trifle too large in the figures. Only the nerves in the right side are shown for a part of the nervous system, where they are duplicated on the opposite side.

PLATE V.



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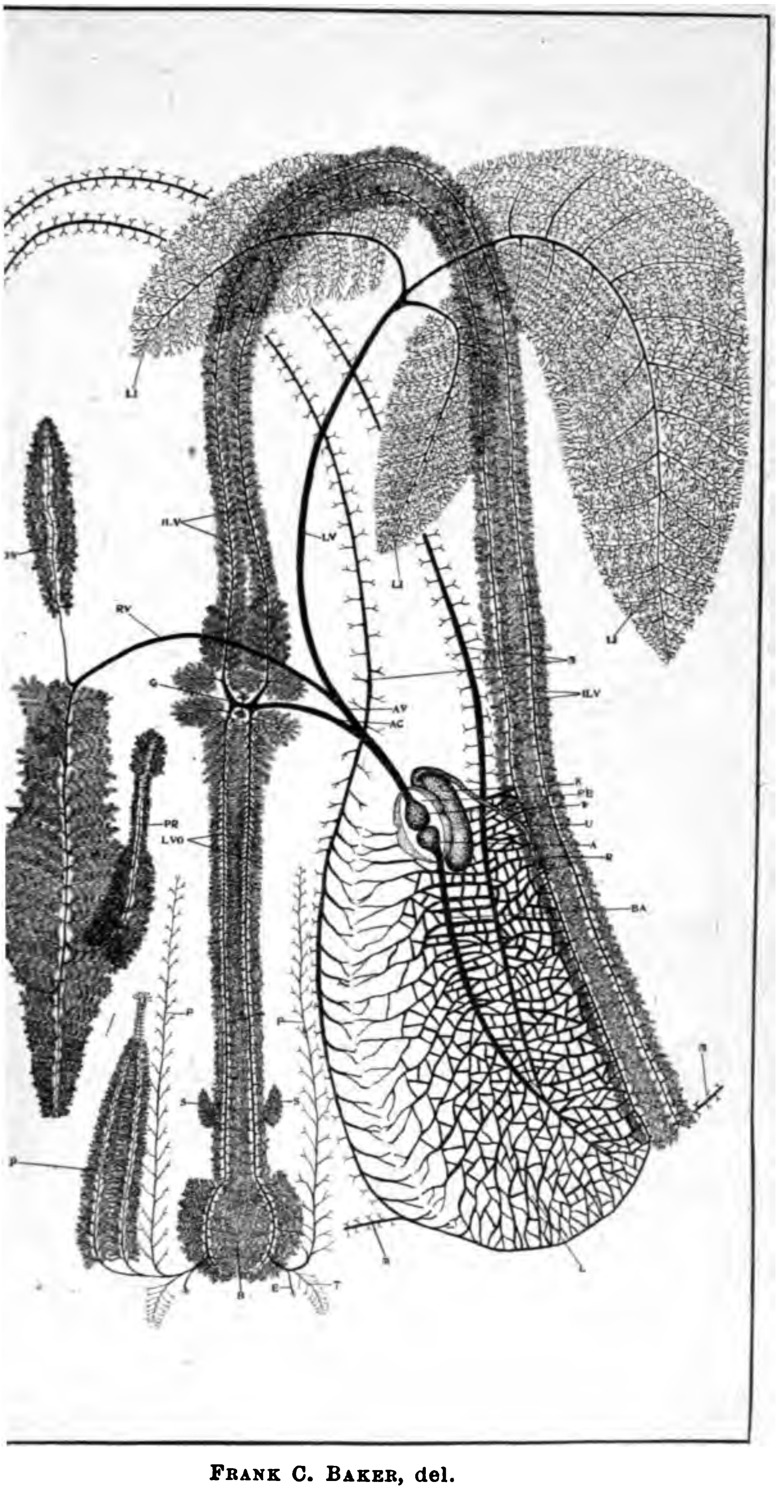
EXPLANATION OF PLATE VI.

A. Auricle.
AC. Aorta cephalica.
AV. Aorta visceralis.
B. Plexus covering buccal sac.
BA. Branchial artery.
E. Vein to eye.
F. Pedal artery.
G. Artery from aorta cephalica which sends branches to gizzard, stomach, intestine, etc.
ILV. Lateral vessels of intestine.
K. Kidney.
L. Lung.
LI. Blood vessels of liver.
LV. Artery from aorta visceralis to liver.
LVO. Lateral vessels of œsophagus.
M. Mantle veins.
OV. Vessels of ovotestis.
P. Vessels of penis sac and penis.
PE. Pericardium, cut open.
PR. Vessel of prostate gland.
R. Rectum.
RS. Vessel of spermatheca.
RV. Artery to reproductive organs, from aorta visceralis.
S. Vessels of salivary glands.
T. Vessel of tentacle.
U. Ureter.
V. Ventricle.
VA. Vessels of vagina.

This plate shows the circulatory system as seen from above, the heart, lung and rectum turned over to the left (hence the lower side is presented), as well as the liver. The arteries and their vessels are represented as though dissected and spread out to show the plexus which they form. The branch of the aorta visceralis, which supplies the generative organs, is represented considerably longer in the figure than it is in nature, this lengthening being necessary to show the branches of the circulatory system.

PLATE VI.



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he Gross Anatomy of Limnæa Emarginata, Say, Var. Mighelsi, Binney.

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BULLETIN OF

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THE GROSS ANATOMY OF LIMNÆA EMARGINATA VARIETY MIGHELSI.—BINNEY.

BY FRANK COLLINS BAKER.

It was the writer's good fortune some time since to receive a number of living and alcoholic specimens of *Limnæa emarginata* and its variety *mighelsi* from Mr. Olof O. Nylander, of Caribou, Maine, for anatomical investigation. So little is known concerning the anatomy of our American Limnæidæ, it was deemed best to make an exhaustive study of this material. In the anatomical notes which follow, the splendid works of Bronn and Keferstein, Moquin-Tandon and Spengel have formed a safe and exhaustive basis of comparison. Of the many species of Limnæidæ found throughout Europe and America, only a few have been studied anatomically. Among these may be mentioned *L. palustris*, *L. stagnalis*, *L. auricularia*, *L. pereger*, *L. megasoma* and *L. truncatula*. In this paper comparisons are made with all but the last of these species. Generalizations and comparisons with allied genera have been reserved for a future paper, when more shall be known concerning our native species. The reader may make these comparisons for himself by consulting the works mentioned in the bibliography. Dr. Joseph Leidy's work on the American Pulmonata (in Binney, Terr. Moll. U. S., Vol. V.), in which are many beautiful drawings of pulmonate anatomy, will serve admirably as a means of comparison with the air-breathing pulmonates.

The material upon which the following notes are based is unusually fine and abundant, including, besides that already mentioned, some 250 specimens of the shells of *L. emarginata* (typical) from Western New York, collected by Dr. Howard N.

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Lyon, and presented by him to The Chicago Academy of Sciences, and 200 specimens of *Limnæa emarginata* var. *mighelsi* from Maine, donated by Mr. Nylander. These two collections show every possible form of this very variable species. In addition to these there are a number of specimens in the collection of the Academy from various localities. The two half-tone plates well illustrate the variability of this species.

About fifty specimens have been dissected and some two hundred and fifty examinations made. Both the typical form of *emarginata* and the variety *mighelsi*, obtained from Maine, have been made a part of this study, but the typical form from New York has not been dissected, as no living or alcoholic specimens were available. The forms from Maine agree in all important details, but whether this would be true of those from New York is uncertain. All of the specimens (with two or three exceptions) were adult, and there was little variation among the different organs. Recent illustrations of the animals of this genus do not, as a rule, show the correct form of the peculiar velum; Lankester's figure 70, in the article Mollusca, Zoological Articles, p. 123, is the only correct recent drawing the writer has seen. The velum varies to some extent among the different species and also among different specimens of the same species, and similar specimens will also vary at different times (see plate III, figures A. B. C.)

In examining this species, marked differences between alcoholic and fresh specimens were observed. The former differed much in color and also in form, the organs being much contracted and distorted. My observations indicate that it is unsafe to describe anatomical details from alcoholic specimens. Accordingly, the notes which follow are taken only from specimens freshly killed by drowning.

The specimens received from Mr. Nylander were kept alive for several months. In captivity the animal is sluggish, remaining for a long time with body and foot contracted and tentacles drooping. The animal is gregarious, forming colonies made up of four or five individuals. During progression the head and velum are raised, the latter moving about in curves. Like all of the Limnæidæ, this species spends long periods out of the water, remaining motionless with its body and head contracted. The first day after the specimens were received several of the rger forms ate one of their number and also defaced several iells by eating their epidermis. Various kinds of food was iven them, some of which they ate with avidity, while other inds were refused. Lettuce was always eaten with an evient relish; bread, apple and potato was always welcome. ake, salt cracker, ginger snaps and cheese were given to them, ut with one exception these were not eaten at all. One iedium-sized specimen seemed ready to eat anything, even heese. Several empty shells were placed in the water to supply he necessary lime for building up the shells.

The living and alcoholic specimens were from Cross Lake, ?ortage Lake, Square Lake and Aroostook River, Aroostook County, northeast Maine. Two miles south of Cross Lake nlet this species was found in large numbers in two feet of water. Mr. Nylander reports that "they seemed to feed on the vegetation on the rocks." (See Nautilus, XI, p. 10.)

I wish to acknowledge valuable assistance received from Mr. Olof O. Nylander, for abundant living, alcoholic and dry material; Dr. Howard N. Lyon, Chicago, for a collection of *L. marginata* (typical); Mr. Frank M. Woodruff, for making the two excellent photographic plates of the shells; Mr. George H. Clapp, Pittsburg, Penn., for dry material; Dr. William H. Dall, U. S. National Museum, Washington, D. C., for notes concernng photographic illustrations and reference to papers for onsultation; Mr. P. B. Randolph, Seattle, Wash., for specimens rom Alaska; Mr. Charles T. Simpson, U. S. National Museum, Washington, D. C., and Prof. William A. Locy, of Northwestm University, Evanston, Ill., for valuable suggestions.

Limnæa emarginata Say. PLATE I.

Limnæa emarginata SAY, Journ. Phil. Acad. Nat. Sci. II, p. 170 21; Narr. of Long's exped., p. 263, 1824; Amer. Conch., vi, pl. iv, fig. 1834; BINNEY'S ed., p. 67, 130 and 311, pl. lv, fig. 1, 1858, HALDEMAN, n. Lim., p. 10, pl. ii, 1841; DE KAY, Moll. of N. Y., p. 73, pl. iv, fig. 1843; LAPHAM, Trans. Wis. State Agric. Soc., vol. ii, p. 368, 1852; c. Phil. Acad. Sci., p. 155, 1860; TRYON, Amer. Jour. Conch., vol. i, 252, 1865; Con. Hald. Mon., p. 110, 1870; BINNEY, L. and Fr.-W. Sh. Am., p. 51, figs. 75–79, 1865; LEWIS, Bull. Buf. Soc. N. H., vol. ii, p. , 1874; INGERSOLL, Rep. Geol. Surv. Terr., p. 406, 1874; AUGHEY, ll. U. S. Geol. Surv., p. 700, 1877; LATCHFORD, Amer. Nat., vol. xviii, 051, 1884; WALKER, The Nautilus, vol. vi, p. 32, 1892; vol. ix, p. 5, ; NYLANDER, The Nautilus, vol. xi, p. 10, 1897.

Limnæa serrata HALDEMAN, Mon. Lim., p. 12, pl. ii, figs. 6, 7, 8, 1841; BINNEY, L. and Fr.-W. Sh. N. Am., p. 52, fig. 78, 1865; TRYON, Amer. Journ. Conch., vol. i, p. 253, 1865; Con. Hald. Mon., p. 110, 1870.

Limnæus ontariensis MUHLFELDT in KUSTER, vide Binney, L. & Fr-W. Sh., p. 51, 1865.

Shell: Of medium size, generally very solid, but varying from thin to thick, globosely ovate, somewhat inflated; color corneous, sometimes very dark, the epidermis plain but sometimes ornamented by longitudinal lighter bands much narrower than the darker band of the ground color of the shell; frequently there will be a broad longitudinal band of white on the last whorl, and the sutures are sometimes bordered with white; nucleus small, smooth, rounded, consisting of two chestnut-colored whorls; surface shining, lines of growth numerous, crowded, frequently wrinkled and sometimes crossed by from eight to twelve spiral ridges, giving the surface a malleated aspect; whorls 5–5½, rounded, more or less inflated, the last large and showing a tendency to expand and flare, and also to become shouldered; spire typically sharp and pointed, but in some forms, particularly the young, it is depressed and very globose and obtuse; sutures deeply impressed, sometimes chanelled; aperture roundly ovate, very large, occupying about two-thirds of the length of the shell, rounded below and somewhat narrowed above, expanded, in some specimens very much so, color dark chocolate or brownish; there is sometimes an elevated, white callus just within the outer lip, bordered with dark brown or red; peristome sharp, thin, expanded to a greater or lesser degree, enamelled, white; columella white, with a strong plait in the middle, covered with a white callus which spreads over the parietal wall and emargines the narrow, deep umbilicus; this callus forms a flaring, spreading margin, completely encircling the aperture. . The aperture is frequently distorted.

Length,	26.75;	breadth,	16.00;	ap. length,	15.00;	breadth,	9.00	mill.,	N. Y.
"	23.00;	"	15.50;	"	14.00;	"	10.50	"	"
"	22.00;	"	14.00;	"	14.00;	"	10.50	"	"
"	19.75;	"	10.50;	"	11.00;	"	7.00	"	"
"	19.00;	"	10.00;	"	10.00;	"	7.00	"	"
"	21.00;	"	11.00;	"	11.00;	"	7.00	"	"
"	18.50;	"	11.50;	"	11.50;	"	8.00	"	"
"	16.00;	"	10.00;	"	10.75;	"	7.00	"	"
"	15.75;	"	10.50;	"	10.75;	"	8.00	"	"
"	18.00;	"	11.50;	"	11.00;	"	7.00	"	"
"	15.00;	"	10.00;	"	10.50;	"	7.25	"	"
"	12.25;	"	9.00;	"	8.50;	"	7.00	"	"
"	16.00;	"	9.50;	"	9.50;	"	6.50	"	"
"	20.00;	"	12.50;	"	13.00;	"	8.50	"	Maine.
"	16.50;	"	10.50;	"	10.00;	"	6.50	"	"
"	11.75;	"	7.75;	"	7.50;	"	4.50	"	"

tribution: Owasco River, foot of Owasco Lake, Cayuga Y.; Hayden's Mills, six miles below Auburn, N. Y.; ıd of Owasco Lake (Dr. Howard N. Lyon); first of four ear Madison, Wis., (P. P. Carpenter); Pigeon Lake, Canada, (George H. Clapp); Aroostook River, Caribou, (Olof. O. Nylander, October, 1895); Madison, Wis.; 'innipeg; Owasco Lake, N. Y.; Lake Superior; Otter ek, Minn., (from Binney, p. 53); Lake Namokin, north Superior; lakes in the Northwest Territory, State of Haldman, p. 11); Anticosti Island, Canada, (Latchfield); Island, Mich., (Walker); Bow River, Nebraska, '); New England to Washington Territory (Ingersoll); n part of Michigan (Walker).

s species is extremely variable, as is well shown in plate I. remes of variation are so great that were it not for the ıt intermediate forms they would be declared distinct The type form described by Say has a long-spired, shell; from this form we pass by an unbroken series to t, stumpy form with a low spire and large, more or less g aperture. It is a peculiar fact that in this genus the species have a long and short spired variety, as is n in *L. catascopium* Say and its variety *pinguis* Say, *L.* Mighels, and *L. stagnalis* Linne and their short-spired . This connection can be seen only when a large numspecimens are examined and compared. The shortırm of *emarginata* connects perfectly with similar forms ariety *mighelsi.*

writer was at first inclined to place both *L. catascopium* '*ecollota* in the synonymy of *emarginata* (in which case have to be called *catascopium*, as this name was given ırs earlier), but the material at hand of these two species ɔt permit of such a disposition. They are closely related, , and future investigation may prove them identical. It to base a decision on the shell alone, but rather on ıination of both shell and animal. The genitalia or r system may possibly give some tangible characters.

specimens from Owasco River are generally graceful and ed forms, while those from Maine are short-spired and owing a decided tendency toward the variety, and the y be said of specimens from Madison, Wis. Unfortunately no specimens of the animal of the typical form were available for anatomical study. The writer hopes to be able to present the results of studies of this character in a later paper.

Limnæa emarginata var. mighelsi. W. G. Binney. PLATE II.

Limnæa ampla MIGHELS, Bost. Journ. Nat. Hist., vol. iv, p. 347, pl. xvi, fig. 1, a, b, c (April, 1843), (Preoccupied by Hartmann for *Gulnaria ampla* described in 1842); Proc. Bost. Soc. N. H., vol. i, p. 129, 1843; BINNEY, Proc. Phil. Acad. Sci., p. 330, 1861; WHITEAVES, Can. Nat., vol. viii, p. 112, fig. 11, 1863; MORSE, Terr. Pul. Maine, 1864; BINNEY, L. & Fr. W. Sh. N. A., p. 30, fig. 34, 1865; TRYON, Amer. Journ. Conch., vol. i, p. 247, 1865; Con. Hald. Mon., p. 91, pl. xvi, figs. 6, 7, 8, 1870; LEWIS, Bul. Buf. Soc. N. H., vol. ii, p. 135, 1874; MORSE, Bul. Essex Inst., vol. xii, p. 172, 1880; WALKER, The Nautilus, vol. vi, p. 34, 1892; vol. ix, p. 4, 1895; NYLANDER, The Nautilus, vol. xi, p. 10, 1897; RANDOLPH, The Nautilus, vol. xii, p. 110, 1899; WALKER, The Nautilus, vol. xiv, p. 8, 1900.

Limnæa sumassi BINNEY (non BAIRD) L. & Fr. W. Sh. N. Am., p. 43, fig. 58, 1865; TRYON, Con. Hald. Mon., p. 91, 1870.

Shell: Large, generally rather thin, very globose, suboval, inflated; color horny, olivaceous green or rich chestnut; the epidermis is frequently eaten away by the carbon dioxide (CO_2) in the water, and is sometimes streaked as in *emarginata;* nucleus consisting of one and a half chestnut or wine-colored whorls, smooth and rounded and rapidly increasing in size; surface dull or shining, lines of growth fine, wavy, crowded, crossed by numerous fine, impressed spiral lines, giving the surface a delicate texture like network; this is absent, however, in some specimens; frequently, large specimens have a number of raised spiral ridges as in the typical form, and in very old specimens the last whorl is "humped" in several places; whorls 5–5½, convex, inflated, shouldered, the last very large, flaring and strongly shouldered; spire varying from obtusely conic to flattened and much depressed; sutures strongly impressed, deeply channelled in some strongly shouldered forms; aperture very large, flaring, roundly ovate, occupying from two-thirds to three-quarters of the length of the shell, rounded below, and either rounded or square above when strongly shouldered, color varying from deep chocolate to bluish-white; the elevated callus of typical *emarginata* is sometimes present; peristome sharp, thin, generally not flaring as in the typical form; columella white, with a heavy central plait, covered with a callus, and reflected over the umbilicus, which it emargines;

the columellar callus spreads over the parietal wall; the lower part of the aperture sometimes becomes so distorted that it spreads far beyond the umbilicus. The columellar plait extends clear to the apex, a fact only seen when the shell is cut in sections; this is also true of typical *emarginata*. The juvenile shells are very globose and gracefully rounded, the shouldered whorls only appearing in nearly adult or old individuals.

Length,	**15.00;**	**breadth,**	**12.00;**	**apert. length,**	**10.50;**	**breadth,**	**8.50**	**mill.**
"	**17.00;**	"	**12.00;**	"	**12.00;**	"	**8.00**	"
"	**19.50;**	"	**15.00;**	"	**13.50;**	"	**9.50**	"
"	**19.50;**	"	**15.50;**	"	**14.00;**	"	**10.00**	"
"	**20.00;**	"	**15.00;**	"	**14.00;**	"	**10.00**	"
"	**16.00;**	"	**15.00;**	"	**12.00;**	"	**9.50**	"
"	**25.50;**	"	**15.50;**	"	**15.25;**	"	**11.25**	"
"	**28.00;**	"	**18.50;**	"	**18.50;**	"	**13.00**	"
"	**25.00;**	"	**17.50;**	"	**17.00;**	"	**11.50**	"
"	**25.00;**	"	**18.00;**	"	**20.00;**	"	**12.00**	"
"	**28.50;**	"	**19.50;**	"	**21.00;**	"	**13.50**	"
"	**29.50;**	"	**21.00;**	"	**21.00;**	"	**13.00**	"
"	**27.50;**	"	**19.50;**	"	**20.00;**	"	**12.00**	"
"	**35.00;**	"	**22.50;**	"	**24.00;**	"	**15.50**	"
"	**22.50;**	"	**19.00;**	"	**17.50;**	"	**13.50**	"
"	**25.50;**	"	**21.00;**	"	**21.00;**	"	**15.00**	"
"	**29.00;**	"	**23.50;**	"	**20.00;**	"	**16.00**	"
"	**32.00;**	"	**25.00;**	"	**24.50;**	"	**17.50**	"
"	**35.00;**	"	**26.00;**	"	**27.00;**	"	**17.50**	"
"	**36.00;**	"	**29.00;**	"	**27.00;**	"	**17.50**	"

Distribution: Square Lake inlet, Cross Lake inlet, Aroostook Co., Maine (Olof O. Nylander); Michigan (T. Jensen); Fort Simpson, British America; Isle La Crosse (Binney, p. 31); northern Maine; St. Lawrence River, English River, British America; Hellgate River and Fort Vancouver, Oregon (Tryon in Con. Haldeman, p. 92); Beaver Island, Lake Michigan (B. Walker); Mid Lake, Maine (Morse); Marsh Lake, near Dyea Valley, Alaska (Randolph); Houghton Lake, Roscommon Co., Mich. (Walker); Eagle Lake, Maine (Morse); Brome Lake, Lower Canada (Whiteaves); British America (Binney); Crystal Lake, Benzie County, Mich., (Kirkland vide Walker).

In the variety *mighelsi* variation seems to have reached its limit. Specimens vary from short, oval with moderately depressed spire to very large with short, almost flat spire, and wide, flaring aperture. It is connected perfectly with the short-spired form of *L. emarginata*, as the figures on the plates conclusively show. No published figures show the wide range of variation in this species, and the writer trusts that the illustrations of this paper will aid somewhat in the identification of this prolific variety. Unlike some species, this form does not vary according to any particular locality, but the same locality will produce all known variations. A naturalist fond of making species could form not only a large number of species, but several genera. Anatomically the animals show no such variation, but are wonderfully uniform. The surface of the shells vary from perfectly smooth to heavily malleated. The plait on the columella is very strong, and is continued to the apex of the shell, as is well seen in a section.

Specimens recently received from Alaska, sent by Mr. Randolph, are identical with those from Maine, except that they are heavily malleated and show a tendency toward scalariform monstrosity. In some specimens the aperture runs off at a tangent.

ANIMAL: EXTERNAL APPEARANCE.

PLATE III, figures A, B, C.

Color generally blackish or bluish-black, head, tentacles and the greater part of the body flecked with white or yellowish white, giving the surface the appearance of being covered with a superficial bloom when the animal is in motion, as described by Dr. Whitfield for *Limnæa megasoma* (Bull. Amer. Mus. Nat. Hist., Vol. I, p. 30, 1881). Foot broadly rounded before, more acutely behind, very broad and much flattened on the margins; color bluish-black, lighter beneath and where it joins the body, flecked with yellowish white spots; the center of the sole is lighter than the edge. Head and velum rather short, ranging in form from semicircular to very wide, with the laterial ends obtusely pointed, according as the animal is motionless or rapidly progressing; the vela area is very large in this species, and frequently assumes a bilobate form anteriorly. Mantle large and conspicuous, fitting closely to the aperture of the shell, bluish-black, flecked with whitish or yellowish. Tentacles broad, flat, thin, triangular and very large and conspicuous, obtusely pointed at their extremity, blackish flecked with yellowish white. Eyes black, surrounded by a yellowish-white zone, placed on rather large swellings at the inner bases of the tentacles. Respiratory ifice placed near the posterior angle of the shell; the so-called siphon" is capable of great expansion, and when taking in r at the surface of the water is sometimes extended to a length nearly a third of an inch. The pulmonary cavity fills about lf of the body whorl, and is colorless and transparent as seen rough the shell, where the heart can also be seen pulsating.

Some animals are lighter than others, the extremes of light d dark being very great. The animal in alcohol is almost jet ack, and the spots are sometimes scarcely visible. In a freshly-lled specimen the liver is yellowish-white, with bright yellow tches here and there, but in alcoholic specimens it turns ownish, as seen through the transparent mantle; the edge of e latter is greatly thickened and fleshy, and is made up of the llowing tissues: an outer thin membrane without cell structure he *cuticle*); an inner layer of columnar, elongated epithelial lls set on end (the *hypodermis* or *epidermis*); several layers of rcular and longitudinal muscles and an inner layer of pave-ent-like cells (*cœlomic epithelium*), with very large nuclei (plate /, figs. I, J).

INTERNAL ANATOMY.

Digestive System (PLATE IV).

Alimentary tract (C). The alimentary tract is similar in general rm and structure to the other Pulmonata, differing only in inor details. The mouth (M) is placed at the anterior end of e buccal sac, into which it opens; the buccal sac (P, N) is mewhat pear-shaped when viewed dorsally, and very much so hen viewed latterally (P); it is very stout, being composed of rong muscle fibres, and contains the jaw and odontophore (J); e posterior side bears the two buccal or stomato-gastric ganglia G); the œsophagus leaves the buccal-sac at the dorsal part of e posterior end (O), and passes to the crop in almost a straight e. The buccal sac is bluish in color, and the œsophagus is rk brown or black. Just posterior to the buccal sac the two livary glands (C, s g) are placed; they are bright yellow in lor, irregular or ramose in shape, and are connected with the ccal sac by four ducts (s D) which enter the latter near the sophagus. A portion of the salivary gland, near one of the cts, greatly magnified (L x 519), shows a very large number small blood vessels and tubes, the former appearing black d the latter white.

The region of the stomach is peculiar and was first correctly noted in American Limnæas by Dr. R. P. Whitfield (op. cit) in *Limnæa megasoma*. The œsophagus first enters the crop (C, D, E, s), which is an elliptical organ when viewed from the dorsal side, but is pyriform when seen laterally; the stomach follows, and at first lies between two very muscular organs, the bilobed gizzard, and then widens into the pyloric portion which gradually tapers to the intestine. The crop and stomach are yellowish in color while the gizzard is almost black. The latter organ is very large, about the size of a small pea, and composed of two concavo convex portions, almost surrounding the stomach, as described above. They are more or less elliptical in outline, and their extremities are connected by a number of stout fibres of a silvery luster, precisely as recorded by Dr. Whitfield (op. cit). The interior is hard and wrinkled, and much resembles the gizzard of a fowl. The latter is as hard as a pea, but the crop and stomach are soft and fleshy. A number of gizzards were cut open; in freshly killed specimens, which had been in captivity for several months, the gizzards were empty, while in alcoholic specimens they contained particles of siliceous matter. The figure of the digestive system of *Limnæa megasoma* in Prof. Wetherby's article * shows this gizzard, although its correct relation to the crop and stomach is not mentioned. The walls of the stomach, crop and gizzard are made up of long muscle fibres, resembling closely those figured in J.. They are all covered with a network of bloodvessels.

The intestine (I) is very long, and is marked by but one pronounced flexure (K, I); it makes one complete turn after leaving the stomach, then follows the course of the last whorl and a half, bends upon itself, and finds an exit in the anus within the mantle cavity (C, A), not far from the orifice of the vagina. The last part of the intestine is somewhat enlarged to form the rectum (C, R). The liver is very large, filling completely all but the last whorl of the shell, and is dark brown in color. It opens by a number of large ducts into the intestine, and into the pyloric portion of the stomach, and is made up, beneath the epithelial layer, of round liver-cells of varying size, which float in a colorless fluid, the cells being yellowish brown (H). The ncreas is well developed, but not conspicuous. The liver is ll supplied with blood vessels which ramify in every direction, ming a complicated plexus. A pair of blood vessels, one on ch side, supply the œsophagus, stomach, intestine, etc., with od. The intestine is made up of the usual tissues (epithelial ing; vascular, circular, etc.,) which need not be dwelt upon re.

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* Notes on Some New or Little Known North American Limnæidæ, by A. G. Wetherby (Journ. Cin. Soc. Nat. Hist., Vol. II, 1879, p. 95, fig. 1).

In general, the alimentary tract agrees with the figures pubhed by European authors. The figure of the general anatomy *Limnæa stagnalis* in Keferstein (taf. ciii, fig. 7) shows this ct very like that of the present species, except that no vision into crop, stomach and gizzard is indicated. Moquin-ndon's figure (pl. xxxiii, fig. 25) of *Limnæa auricularia* is nost identical, but his figure of *L. stagnalis* (pl. xxxiv, fig. 18) ffers in the form of the stomach, which does not show the visions indicated above.

Dr. Whitfield mentions a gizzard-like body in specimens of *stagnalis* from Sodus Bay, Lake Ontario, (Am. Mus. Bull., 37) which closely resembles that in *L. megasoma*.

The Jaw or Buccal Plate (Pl. iv, fig. M. P. J).

Only one buccal plate was found, and this the large superior w. The lateral jaws found in most of the Limnæidæ were parently absent.* The single jaw is large, very wide and w, the dorsal margin is gracefully arched and smooth while e ventral margin is roughly serrated, with an irregular central ojection. The anterior face is striated, and the color is rk brown, almost black in some specimens. Where the jaw ns the supporting ligament it is much lighter in color than is e cutting edge. The jaw is placed in the upper part of the outh at the extremity of the buccal sac (P, J).

The Radula (Pl. iv, A. B.).

The odontophore is more or less quadrangular in form when read out, and is about twice as long as wide. There are about e hundred and thirty rows of teeth, each row corresponding to e formula 35–1–35 (6-14-15-1-15-14-6). The central tooth) is long and narrow, unicuspid, with the lower outer angles of the base of attachment much expanded and produced. Lateral teeth with a subquadrate base of attachment, the lower outer angle somewhat produced; reflection large, reaching below the edge of the base of attachment, bicuspid, the inner cusp (mesocone) very large, symmetrically rounded and terminating in a sharp point; the outer cusp (ectocone) very small, rather long and narrow, the extremity rather sharp and in some cases pointed inward toward the inner cusp; in several radulæ (A, 2) examined the second lateral had a swelling on the inner side of the inner cusp which probably represented a tendency to form a third cusp (entocone); the intermediate teeth are, for the most part (A, 16, 17, 20, 21), characterized by long and narrow cusps, the base of attachment being short and almost square; they are tri- or penta-cuspid; the teeth first break into tricuspids (16) by the appearance of an inner cusp, which is modified or breaks off from the inner part of the inner cusp, near the distal end; this soon (20) breaks into three cusps, all being at the extreme distal end of the reflection, the outer and inner cusp being of good size with rounded extremities, while the third or middle cusp is very small and sharp or thorn-like; the original outer cusp here breaks into two small, thorn-shaped cusps (20) placed well up on the outer margin; toward the end of the membrane the teeth become very long and narrow, the small inner cusps disappear and the distal ends become 4 or 5-serrate.

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*As the lateral jaws are frequently difficult to make out, the writer desires to alify this remark by adding that he was unable to find any jaws, save the large perior jaw, in any specimen examined, search for the lateral jaws being carried very carefully.

A single radula examined (B, 11, 14, 15) had the first intermediate tooth distinctly tricuspid, the endo-, meso and ectocones being as well marked as in the Helices (11). The fourteenth tooth had the outer cusp broken into two short, rounded cusps, placed side by side; the fifteenth tooth had three equal cusps at the distal end of the original inner cusp, while the outer cusp was as in the lateral teeth; all of the other teeth were normal. As an example of the Limnæidæ, the radula was remarkably constant in the form of the teeth.

Genital System (Pl. III, figs. D. E. F. G).

Male organs (E). As in the Limnæidæ generally, the male and female organs are separate (with the exception of the hermaphrodite gland) and open by separate orifices, that of the male being behind the right tentacle and that of the female at the base of the neck, near the pulmonary opening. The penis sack (P. S.) is very large, of great length and large diameter; it is wide at the exterior opening, but narrow at the end where the penis is attached. The penis (P.) is half the length of the penis ack, very long and slender, with a rounded head, about two and one half times the diameter of the neck of the penis. The penis and penis sack are retracted and protracted by a set of powerful muscles (RM, PSM). There is a long, hair-like flagellum (F) which extends from the head of the penis to the orifice of the penis sack. A nerve starts from the cerebral ganglion (CG) and after extending for a short distance divides, one branch running o the head of the penis and the other innervating the penis sack (PN, PSN). The penis is generally yellowish in color, sometimes very bright, while the penis sack is grayish (in alcohol) or yellowish (living). The muscles are white in color. The vas deferens (VD) extends from the head of the penis to the columella muscle (CM), where it becomes lost in the muscular tissue; it reappears at the opening of the vagina, where it becomes the duct of the prostate (PD); this duct is rather long, very narrow, and enlarges on the side of the vagina into the prostate gland (PR) a cylindrical, fleshy organ, well supplied with blood vessels, and of a yellowish or amber color. Posterior to the cylindrical portion, the prostate becomes very much narrowed and flattened, whitish in color, and near the albuminiparous gland again enlarges into a much folded organ of a grayish color. From this point the hermaphrodite duct passes to the hermaphrodite gland.

Female organs (D. F. G.). The hermaphrodite gland or ovotestis is made up of a number of rounded or lobulated follicles which have the form shown in figure F when greatly enlarged. The gland is yellowish in color. The ovisperm duct or hermaphrodite duct (OD) extends from the lower part of the ovotestis to the albuminiparous gland, from which it divides, one part forming the prostate and the other the uterus. The albuminiparous gland (AL) is large and rounded, of a greenish color, and made up of quadrangular, pentagonal and hexagonal cells (G), with rather thick walls and filled with granular protoplasm, the granules in the center of the cell being very large. The uterus (U) is at first trilobed, then becomes smaller and rounded, then swells into a large, fleshy, cylindrical sac; the vagina (VA) then contracts to form the vestibule or atrium (A) and finds its exit behind the male orifice and near the respiratory orifice. The uterus and vagina are yellowish in color and the walls of these organs are made up of strong muscular tissue. The spermatheca or receptaculum seminis (S) is elongate-oval in form, of a pearly white color and connected with the vagina by a long, narrow duct (SD), which enters the latter near the cylindrical portion of the prostate, just above the atrium. The vagina is supplied with two stout retractor muscles (VM). A single nerve (VN) supplies the vagina from the right visceral ganglion. All of these organs are well supplied with blood vessels.

In the natural position the ovotestis is folded in the lobes of the liver and is very strongly attached to that organ. In some works a testicle is described for certain species of the Limnæidæ, viz., *L. megasoma* and *Pompholyx leana* var. *solida*, but no such organ could be found in any of the specimens examined, nor is any described in European works.*

Keferstein's figures of the genitalia of *L. stagnalis* (taf. ciii, fig. 8) agrees with that of the present species in a general way, the difference being that that species has no flagellum, the penis sac is shorter, the prostate more bulbous and not cylindrical, and the spermduct enters the atrium lower down. In fact the female genitalia may be said to be longer and more generally cylindrical in the species under discussion than in *L. stagnalis*. Moquin-Tandon's figure (pl. xxxiv, fig. 27) of *L. auricularia* shows the male organ similar, though the penis is not clearly shown and there is no flagellum. The female genitalia is quite different, but this may be because it was drawn from a different position; *L. stagnalis* (pl. xxxiv, fig. 19) is similar to that figured in Keferstein, and shows about the same differences. None of these figures show the innervation of the male and female genitalia. The vas deferens is not shown in Moquin-Tandon's figures as coming directly from the head of the penis, in fact there seems to be no sharp division between the penis and penis sac in the figures of these two species. Lacaze-Duthiers' figure of *L. pereger* (pl. 17, fig. 2) shows the same innervation of male and female genitalia as the present species.

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*It is generally conceded that in the androgynous gastropods the ova are borne on the exterior and the spermatozoa on the interior of the individual follicles.

Vol. II. No. IV.

BULLETIN

...OF...

The Chicago Academy of Sciences

1. The Digitations of the Mantle in Physa.

2. Description of a New Species of Limnæa.

..BY..

FRANK COLLINS BAKER
Curator of The Chicago Academy of Sciences.

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1 THE DIGITATIONS OF THE MANTLE IN PHYSA.

FRANK COLLINS BAKER.

If the edge of that part of the mantle of Physa which is reflected over the parietal wall is examined, it will be found to consist of a greater or less number of little finger-like digitations and the fact will also be noted that these projections are placed in two series, one near the umbilical region and one at the posterior extremity of the aperture, a simple or smooth space of the mantle edge connecting and lying between these two series. A more detailed examination will show that the form, number, and general position of the digitations vary in a wonderful degree in different individuals of the same species. In the present paper several of our common species are discussed.

American literature contains but few references to the digitate mantle of Physa. Haldeman says,[*] "Inner and posterior edge of the mantle digitate." Binney says,[**] "Mantle covering part of the shell, the margin fringed or digitate." Thomas Say, whose careful delineation of species is unsurpassed in American conchological literature, says of the animal of *heterostropha*:[†] "The mantle is trifid at the base of the pillar lip and at the upper corner of the aperture.

These references show that little or no attention has been paid to the study of this part of the animal.

The material upon which this paper is based was personally collected in Providence, R I., Rochester, N. Y., and Chicago, Ill. Many specimens have been examined, including individuals of all ages. The writer has been struck with one fact which stands out prominently, that the species with shell exhibiting little or no variation, as *Physa integra*, had the marginal digitations very uniform, while in those species subject to great variation, as *Physa gyrina*, there was a corresponding variation in the mantle margins, which fact shows that the shell and animal are correlated as to variability.

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[*] A Monograph of the terrestrial Univalve Mollusca of the United States. Physidæ, p. 29, 842. Tryon, Contr., p. 125.

[**] Land and Fresh Water Shells of North America, part II, p. 75, 1865.

[†] Binney, Land and Fresh Water Shells of North America, p. 24.

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The writer is indebted to the following persons for assistance in either notes or specimens: Mr. Bryant Walker, Detroit, Mich., and Mr. Harry S. Hall, Rochester, N. Y.

In the following descriptions the region of the posterior part of the aperture will be termed the apex and the columella region the columella.

Physa integra Haldeman, pl. 1, A, B.

The mantle margins of this species are very uniform. The normal form has 3 rather long, narrow digitations at the apex and 4 in the columella region (B). About two per cent. of the specimens examined had 5 digitations in the columella region and 3 at the apex (A). A very small percentage had 4 short digitations at the apex and in one or two specimens the apical digitations were very small or wanting. Over fifty specimens have been examined.

Physa integra is common in the Erie Canal and Genesee River, where it is very uniform. The white, thickened lip of this species is very characteristic, and the majority of specimens have the various rest periods marked as white longitudinal stripes on the older whorls of the shell. When alive the white lip is the most conspicuous part of the animal.

Physa gyrina Say, pl. 1, C to I, L to O.

As might be expected, the mantle margins vary more in this species than in any other member of the genus which has been examined, thus being coördinate with the variation in the shell. The normal form appears to have 4 long, narrow, equal apical digitations, and 6 in the columella region, the latter having central projections somewhat longer than those on either side, as shown in figure M. From this type the variation is almost endless. The digitations at the apex vary from 2 (I) to 5 (M), and any one of the projections may be short and stumpy (H) or very long and slender (L); or the entire apical portion of the mantle may be made up of 4 small, rounded knobs (C). The digitations in the columella region are also very variable. The smallest number seen was 4, small and finger-like (C), and the largest 10, of which 5 were very large and long and 5 were very short, 2 on one side and 3 on the other (N). Several specimens examined had 6 columella digitations, in which there were 2 long projections with a small tubercle on each side (L).

iother variation, seen in several specimens, was 3 large and l digitations (G. O.), and in a number of individuals the r was 8, all of which were nearly equal (F).

ie greatest variation was found among specimens from the :e River and the Erie Canal. Several specimens from ence, R I., were very uniform, the extremes of variation ipex 2, columella 5 (I), and apex 5, columella 6 (H). Mr. Walker finds the Michigan *gyrina* to vary as follows: apex, columella, 3 to 6. The numerous figures on the first plate he extremes of variation, both in number and form.

ieterostropha Say, pl. I, J, K.

.is species does not exhibit the variation shown in either or *sayii.* The normal form has 4 digitations in the apical n the columella region. The apical projections vary from and the columella from 4 to 6. The digitations are very n in size, being rather long and tapering.

dging from the writer's experience in Physæ, *heterostropha* e rare, instead of being very common, as is generally re- . No undoubted specimens have been seen from Rhode and in western New York it is rare, as is also the case in rn Illinois. It should be borne in mind that the shell of *ropha* is smooth, while that of *gyrina*, *sayii*, and others is ed by fine, impressed, spiral lines.

ayii Tappan, pl. 2.

though the shell is quite uniform in *sayii* the mantle mar- iow a wide range of variation. The normal form has 4 digitations and 5 columella digitations (H). The former om 4 to 5 and the latter from 4 to 8. In form they are long and tapering, although a few are short and stumpy, . One specimen had a split digitation in the columella (H), and several specimens had all the projections very ounded, and stumpy (G). The plate shows these varia- ufficiently.

inosa Gould.

. Bryant Walker has given me the following data for this : The digitations were longer and more slender than in four out of six examples had 5 columella digitations and d 4 columella digitations, while four specimens had the digitations 3, and two had 4.

Physa traskii Lea.

Specimens of this species recently collected by Mr. Frank M. Woodruff, at San Diego, Cal., exhibit the following variations: apical digitations 3, 4, 5; columella 5, 6, 7, 8. The digitations are generally very uniform, long and tapering, but occasionally the variation in size is considerable, as in the figure of *sayii* on plate II, figure E.

When the writer began these investigations he hoped that in them he would find some help in drawing specific lines in this very variable family. Such has not been the case, however, for nearly all of the species vary greatly and all seem to have about the same range of variation. It was thought that the digitations were, in a measure, able to contract and expand, but there is not evidence enough as yet to establish this as a fact beyond question. Several species appeared to have this power over the digitations of the mantle. This is a subject for future investigation.

COMPARATIVE TABLE OF VARIATION.

Integra.			Gyrina.			Heterostropha			Sayii.			Traskii.			Vinosa.		
A*	C	N	A	C	N	A	C	N	A	C	N	A	C	N	A	C	N
0	4	2	2	4	4	3	4	4	4	4	7	3	5	2	3	5	4
3	4	49	2	5	1	4	5	14	4	5	27	4	5	6	4	4	2
3	5	3	3	4	4	4	6	2	4	6	6	5	6	2			
4	2	2	3	5	6				4	8	2	5	7	1			
4	3	2	3	6	8				5	6	2	5	8	1			
4	4	2	4	4	20				5	7	3						
			4	5	25				6	6	3						
			4	6	100												
			4	7	10												
			4	10	6												
			5	4	11												
			5	6	25												
			5	8	30												
		60			250			20			50			12			6

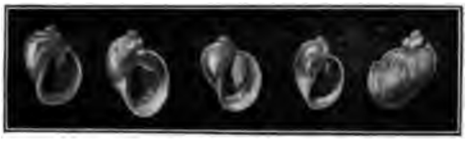
* A anterior; C columella; N number of specimens examined.

2 DESCRIPTION OF A NEW SPECIES OF LIMNÆA.

FRANK COLLINS BAKER.

Limnæa woodruffi sp. nov. Text figure.

Shell: Ventricose, very much inflated, solid; color greenish horn or olivaceous; surface shining, growth lines distinct; rough in some specimens, crossed by numerous fine impressed spiral lines; apex small, rounded, light horn colored; whorls 3–4, rounded, inflated, the last occupying nearly the whole of the shell; spire depressed; sutures impressed; aperture very large, roundly ovate, occupying about four-fifths of the length of the entire shell, roundly shouldered at the upper part; peristome thin, sharp; columella thickened, spreading, with a plait or fold in the middle; the lower part of the aperture is expanded, the columella callus making a ridge which is reflected over the umbilical region; umbilicus open, deep.



Length 12.50; width 8.00; aperture length 8.50; width 5.50 mill.

Length 11.00; width 8.00; aperture length 8.00; width 5.00 mill.

Length 11.50; width 8.00; aperture length 8.00; width 4.75 mill.

Animal, Jaw, Radula and *Genitalia:* Not examined.

Distribution: Southern part of Lake Michigan.

Habitat: Probably similar to *catascopium* and *emarginata.*

Remarks: This species has puzzled the writer for many years and has been referred to both *decollata* and *catascopium.**

It certainly is not any form of *catascopium*, and, judging by the figures in Binney, Haldeman and Tryon, it is not *decollata.* Specimens of the latter received from the Philadelphia Academy of Sciences are decidedly different, the spire being longer, the number of whorls less and the shape of the aperture is dissimilar. The principal characteristics of *woodruffi* are its very short spire, rapidly increasing and swollen whorls, and its roundly oval aperture with its broad shoulder at the upper part. It looks not unlike a miniature *Limnæa emarginata*, variety *mighelsi*. The present species has been described as new for the reason that in a lot of some two hundred specimens no individual has been found connecting it with any known form. It has been found at Millers, Ind., and along the lake shore in Chicago, by Mr. Frank M. Woodruff, to whom the species is dedicated.

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*In the writer's paper on the Limnæa of Northern Illinois, in Trans. St. Louis Acad. Sci., Vol. IX, No. 1, pl. i, fig. 12, this form was referred to variety *pinguis* Say. The receipt of a large number of specimens has demonstrated that it is not that form.

PLATE I

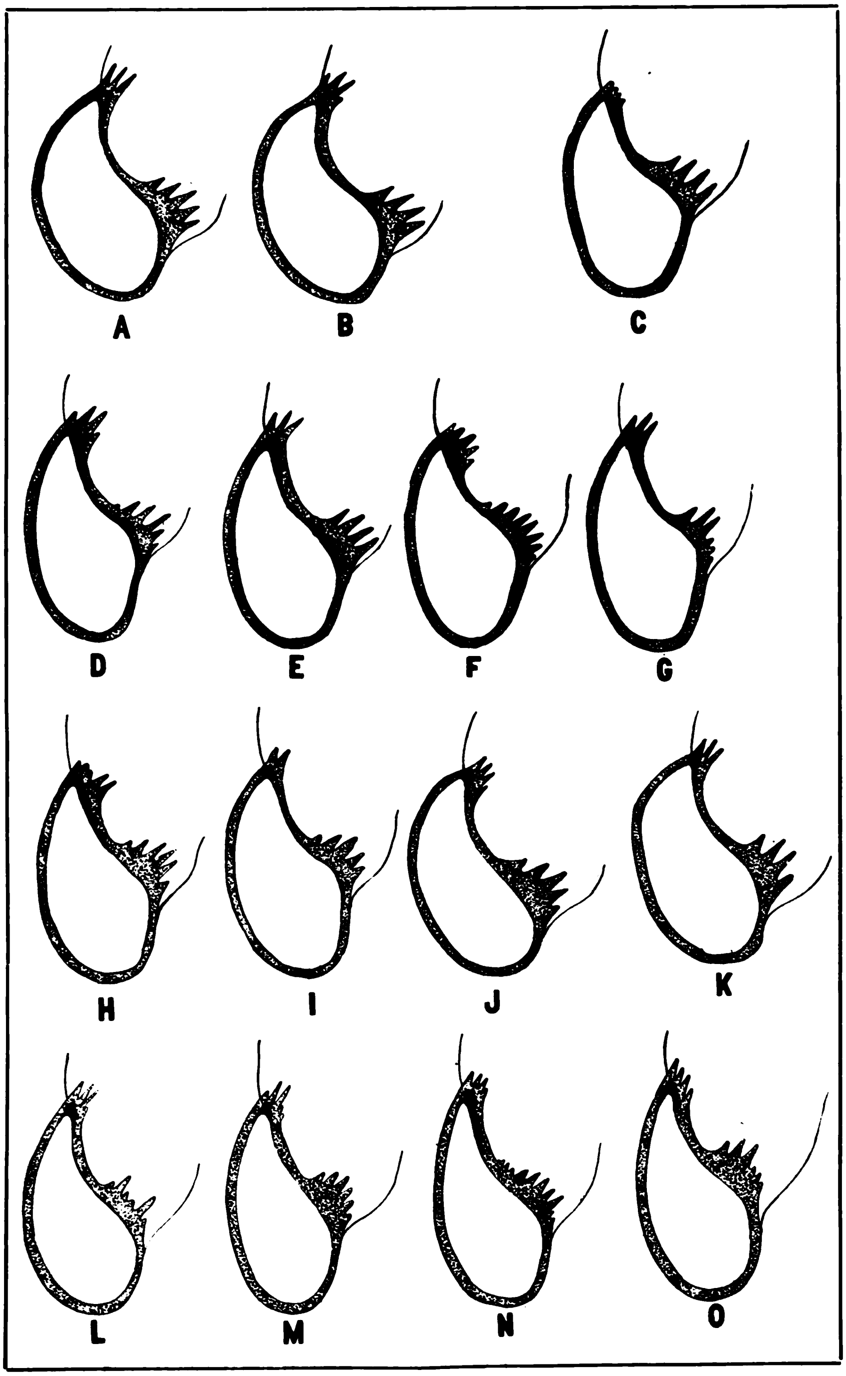
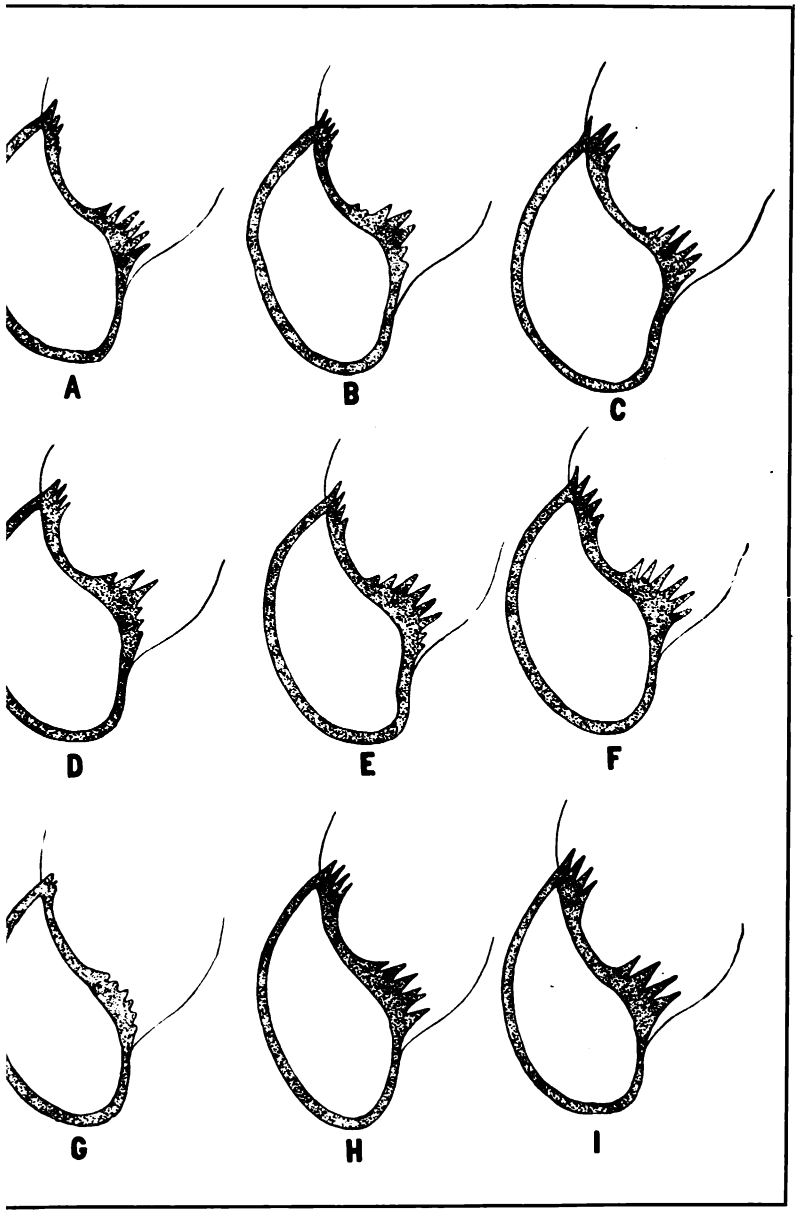


PLATE II.



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